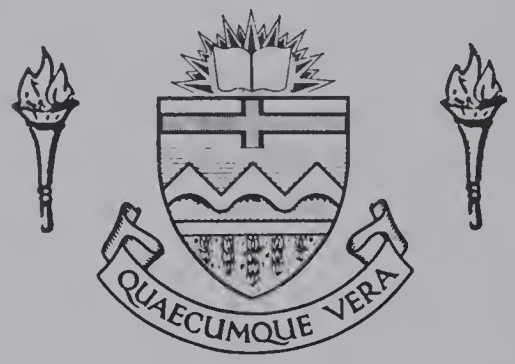

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THE OUTPUT AND SOURCES OF INVENTION IN CANADA AS MEASURED BY PATENTS

by

© ROBERT W. KORUNA

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Output and Sources of Invention in Canada as Measured by Patents" submitted by Robert W. Koruna in partial fulfilment of the requirements for the degree of Master of Arts.

ABSTRACT

This thesis is an examination of the output and sources of invention in Canada during the Twentieth Century. Patents serve as the vehicle for examining inventions as they are the most complete and least subjective index which is presently available for this purpose.

Historically, there has been a decline in the number of patented inventions produced per capita since the early 1920's. Accompanying this decline, has been a switch in the source producing the greatest number of patented inventions from independent to corporate inventors.

In comparing Canada's output per capita with that of selected other countries, these countries accounting for over ninety per cent of the patent applications in the world in 1968, it was found that Canada appeared well down the list.

ACKNOWLEDGEMENTS

I would like to thank Professor Frank Roseman for his constructive guidance and efforts on my behalf. I am also indebted to Professor Max Stewart for his timely assistance.

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INTRODUCTION

As with many other areas of study concerning the development of Canadian society, the production of inventions by Canadians has been largely ignored by Canadian scholars. Because of this, adequate statistics on inventions are lacking and there is also a lack of useful analysis of the process of invention in Canada. Such weaknesses have not gone unnoticed.

> The importance of technological advance in economic growth, rising productivity, and international competitiveness points strongly to the need for a deeper understanding of the strategic elements that promote and contribute to technological progress and to many of the processes of change which are at the heart of economic growth.[1]

The study of technological progress involves a wide range of subjects including applied science, engineering knowledge, invention and innovation. Rather than skimming over all of these, this thesis will focus on invention and handle it in more depth. It is reasonable to take this position since, although all four of these branches of technology are interrelated, invention and innovation "constitute the payoff, the only forms in which scientific and engineering progress can directly affect economic activity";[2] moreover, innovation typically follows invention.

While the study of invention might be said to fall within the jurisdiction of a number of the social sciences, it is necessarily an economic question since it involves the allocation of scarce resources which could be applied elsewhere. "It represents in essence the mobilization of a society's creative energies to relieve the scarcities which existing resources and products cannot."[3]

This thesis will examine the state of invention within Canada during the twentieth century. To accomplish this aim, the thesis has been structured into four chapters, the first being the Introduction. The second chapter is the base on which the thesis rests. It concerns the validity of patents as an index of the total production of inventions in Canada. The more confidence that can be placed in patent statistics for this purpose, the more reliable the results of this study are, and I believe that patent statistics can be shown to be highly viable in this regard. The third and fourth chapters form the body of analysis in the thesis. The third chapter describes and examines the short run fluctuations and long run trends of patented inventions in Canada with discussion of the factors that may have led and contributed to these trends. Special attention will be paid to several of the characteristics which constitute Canadian patented inventions. While this third chapter provides much information, its utility is limited since there is no standard for comp-

arison. To correct this situation, the fourth chapter will make comparisons between Canadian production of inventions and that of other countries. Principally, there will be a detailed comparison of the production of inventions in Canada and in the United States and, in addition, a comparison with twenty-four other countries for the year 1968. This will be done in order to give perspective to the results achieved in examining the Canadian statistics alone, and will hopefully allow for a realistic appraisal of the Canadian output of inventions.

Of course, this thesis is only concerned with one part of one dimension in the study of invention in Canada. However, as it invades an area of study that has only been touched before, information that is both new and more complete is presented.

CHAPTER 2

PATENTS AS AN INDEX OF INVENTIONS

Since patent statistics are being used as the primary data for this thesis, it is important to discuss their validity as an index of the output of inventions, in order to correctly interpret the results of this investigation. In this chapter, the arguments concerning the use of patent statistics will be discussed, and the areas for concern in their interpretation will be pointed out. Thus, this chapter is included to explain the reasons why it is felt that patent statistics are suitable for achieving the aims of this thesis as they were set out in the Introduction.

It is helpful to define the term invention so that its use does not cause confusion.

> Invention means any new and useful art, process, machine, manufacture, or composition of matter, or any new and useful improvement in any art, process, machine, manufacture, or composition of matter.[1]

This is the definition that is given in the Canadian Patent Act of 1935 and therefore illustrates what the Canadian Patent Office would consider a patentable invention to be. By using this definition, social inventions, or those that induce society to compete and co-operate for social progress, are ex-

cluded. In part, this is an advantage, not because social inventions are unimportant, but because the methods used to produce them are not easily discernible or measurable; they must be excluded from this examination since there is no body of information through which their identity can be easily discovered. Therefore, this discussion revolves around technical inventions, that is, new products and processes or substantial improvements in existing products and processes. To dissect the definition further, the requirement of newness serves two purposes: to differentiate an invention from an innovation, and to eliminate duplication in measuring invention. The term innovation is used here to mean "a modification which a skilled practitioner in the art can be expected to make in a product or process to adapt it to minor changes in material, function, site, and so on."[2] Note that this definition of innovation is unusual, but because only technical inventions are being discussed here, it fits the situation much better than the normal, broader definition. In regard to duplication, two identical inventions do not add to the existing stock of knowledge as would two different inventions, and therefore our concern is with the first of the two identical inventions, the one that received a patent. Kuznets has stated:

> It follows that an interest in the input of inventive capacity and a technological measure of inventive activity would require that an invention be defined as an independently derived, rather than a new, device; whereas, an interest in the output of

> inventive activity as a contribution to technical knowledge would require that an invention be a new device in the sense of contributing a real addition to the stock of available knowledge.[3]

Since this thesis is examining the Canadian output of inventions, the requirement of newness as it is embodied in the Canadian Patent Act is what is desired. If inventive capacity were being examined, then whether one, two, or a dozen inventors produce identical inventions would be important; but as it is only the first inventor that must be known for this thesis, then the Patent Record supplies the information that is needed. If the other inventors, who produce identical inventions, gain any additional knowledge in their work that would be desired by society, then this could appear in a new invention or as an improvement of the existing patented invention. This, then, would receive a patent and appear in the statistics.

In regard to the criterion that an invention be useful, it is perhaps better to substitute the word workable for the word useful. This is because it would be difficult for patent officials to judge the potential usefulness of every invention, especially with inventions that may be radically new. If all inventions were useful, then supposedly each invention should come into commercial use, and this is not the case. Rather, inventions that are granted patents are workable; that is, they are capable of fulfilling the claims that are made of them, and are not merely concepts

which may be feasible. It is also to be hoped, although this meaning should not be imputed to the formal definition, that patented inventions are useful in an economic sense; that is, that an invention be a practical good which "either reduces the cost of producing already established goods or makes possible the production of new goods for which the demand is sufficient to cover costs."[4] This is not always the case, although I believe it is becoming the more typical situation. Presumably, one is coming closer over time to the point where patents will become an index of economically workable inventions, particularly in the corporate sector. A utilization study, such as that carried on by Barkev Sanders for the United States, would be of some help in determining how strong this tendency is. The problem with relying on utilization studies is that frequently the economic value of an invention is not recognized, especially with regard to the inventions of independent inventors. J. J. Brown, in his book on important Canadian inventors, Ideas in Exile, presents several such examples where important inventions were produced in Canada, but not developed in this country.[6] The value of the ideas was later recognized elsewhere and commercially exploited. Several of these examples are: the variable-pitch propeller, the hydro-foil boat, the Jetliner, automatically controlled machine tools, and the electric organ. As an illustration, the electric organ, which was first invented in Canada by Robb, was later developed by

Hammond, and that company today has sales of over three hundred million dollars a year.[7] Therefore, the percentage of economically workable inventions may be higher than that which would be shown by a utilization study.

Patent statistics are an index of the number of technological inventions made within an economy over a period of time. They are the best record of invention presently available and are the only source of information that can be used to examine inventions made in the past. The form of patents allows a large amount of information concerning the character of inventions in Canada to be gathered fairly simply, although many hours are needed to get it. Patent information has the advantage of isolating invention from scientific discovery and innovation. This is an advantage, for it is the invention that leads most directly to economic progress. This is not to negate the importance of scientific discovery, as it is the springboard for all inventions, nor to negate the importance of innovation which adapts most inventions to their specific purposes.

The validity of patent statistics as an index of invention depends mainly on the completeness of the Canadian Patent Office Record as a record of inventions.[8] This again depends on the definition of what is a patentable invention, which has already been examined. The more restrictive that this definition becomes, the less valuable it is as an index

of invention. As has been pointed out, the official definition used in Canada restricts itself to physical inventions. In the United States, for example, designs and botanical plants may be granted patents, although they are numbered separately, while in Canada, there is separate industrial design legislation rather than including these in the Patent Act. Both countries exclude social inventions which may have important economic significance. While using the definition of invention as it is given, we must recognize that not all inventions that are made are patented. Since there is no record of these inventions that are not patented, it is impossible to evaluate the completeness of the Patent Record. For example, Barkev Sanders reports that approximately 40% of patents assigned to corporations, in his study, were used commercially before filing a patent application.[9] This indicates that at least in modern times many inventions are tested prior to applying for a patent and many will not be patented because they are not commercially feasible. Thus, patents, as an index of invention, are weakened, although there is no way to calculate what proportion of inventions are not patented as a result of this practice. It has been suggested that inventions may not be patented because of a desire for secrecy, because of doubts about the economic possibilities of the invention, or because of indifference to the profit possibilities of the invention.[10] The third of these reasons is unlikely to have a significant influence

on the validity of patent statistics, for there is a cost to inventing that must be covered. Similarly, the second reason would not seem to have a significant influence with individuals, although it has already been noted that corporations may be reluctant to patent inventions that have been found to be not commercially feasible. Individuals attempt to patent inventions for possible gain and for prestige. The fact that the invention may be frivolous or impractical, or a duplication of an existing patented invention does not seem to matter as is pointed out in the introduction to J. J. Brown's The Inventors. ". . .there are one hundred variations on the can opener registered every year in Canada alone."[11] As for the corporations, inventions that are not patented because they are not commercially feasible may provide additional technical knowledge which may appear in another invention or an improved version of the first invention and this may be patented if it has commercial possibilities. Thus, the invention does not necessarily go uncounted, but rather there may be a longer lag between the time it is first invented and when it has been developed well enough so that the inventors patent it.

The first reason given was secrecy. The reasons for using secrecy may be a belief that the patent right is insufficient protection and imitation may be easy, or that

there is an expected life for the invention of longer than that granted by the patent although this would not appear to be the case very frequently in today's society. Scherer, in Patents and the Corporation, pointed out that "a firm can benefit greatly in prestige from being the first in the market with a new product, or can enjoy a good deal of control over the prices of its products because it customers believe the company is technological leader in its field."[12] Secrecy is less likely to be a factor in Canada than in the United States, for one of the main reasons given by corporations in the U. S. A. is the uncertainty in the area of patent validity - the fear that the privilege of the patent will be negated by compulsory licensing or denied because of the firm's powerful influence in an industry.[13] One other explanation for secrecy is that an invention is, in fact, an infringement on an existing patent, in which case it is not a new invention and nothing is lost by not having it included as it would not be granted a patent. Since it is difficult to believe that an important Canadian invention with potentially widespread commercial use would not be patented, I suggest that secrecy is not likely a widespread practice in Canada, but once again it is impossible to know how widespread a phenomenon it is since the inventions are kept secret. However, research carried on in Canada by U. S. subsidiaries may well lead to keeping inventions secret when this is the practice of the parent firm, espec-

ially when the Canadian inventions are related to the inventions held secret in the United States.

On the other side, there is the possibility suggested by Merton that there may be more patents than inventions.

> The possibility of obtaining patents for processes or devices slightly different from those already in use frequently leads to 'alternate' or 'blocking' patents in order to protect an invention. This serves to swell the number of patents without denoting a larger number of inventions.[14]

For example, a corporation may develop an invention which reduces the cost of an operation by one-half. In order to strengthen its own market position, the firm will patent other inventions that are similar to the main invention, but only reduce cost by one-quarter and one-third. The firm has no intention of using these supplementary inventions but it is now in a position to block their use by competitors. This is an aspect of the general phenomena of "fencing out" competing inventions. Machlup stated in an examination of the abuse of the patent monopoly that:

> Indignant complaints have been raised. . .against the taking out of patents not to work the patented invention, but to keep others from working it, especially to 'fence out' possible competing developments of the patented invention or to 'fence in' the competition by blocking possible developments of inventions patents to them.[15]

This would seem to suggest that such practices occur fre-

quently in the United States, and there is no reason not to believe that this same type of thing occurs in Canada.

As patents issued have been chosen for use in this study instead of patent applications, it is appropriate to explain the reasons for this choice in terms of the advantages of each. Schmookler, who is the major exponent of patent use, favours patent applications to patents issued.[16] However, Schmookler was using patents as an index of inventive activity, while in this thesis, patents are being used as an index of invention. Patent application statistics are dated closer to the dating of the actual invention and this is the main advantage for Schmookler's work. In this thesis, this is not an advantage. This is because the data for other countries and now for Canada are not broken down as to the source for inventions in patent applications - that is, the category of Independent, Corporate and Government. Thus, if patent applications were used, invention per capita by source comparison with other countries would not be possible.

Schmookler sees patent applications as having a fuller coverage of the phenomenon of invention since they are not influenced by the exigencies of the officers of the Patent Office. I must quarrel with this argument for, although some inventions fail to be granted a patent, many more non-inventions (those not deserving patents)

will be included in error. This conflict arises because Schmookler was trying to measure inventive activity, while in this thesis, inventions alone are the source of study. Those inventions which are neither new nor useful are not inventions and will not receive a patent. Including these non-inventions will only weaken the validity of the patent statistics and would be harmful rather than beneficial to this study.

Therefore, patent statistics gathered from patents issued are the best available index of Canadian production of inventions. They are the most complete and least subjective source for Canadian inventions. By using patents issued, the comparison of Canadian inventiveness with other countries on a source of invention basis is possible. The statistics that have been gathered allow for a historical breakdown of Canadian invention so that an analysis of what has and is occuring in Canada can be studied in depth. What is being examined is the output of Canadian inventive activity; to go further afield with this data than is done here would require many highly restrictive assumptions and the results would have to be viewed with caution.

CHAPTER 3

DESCRIPTION OF THE TRENDS IN PATENTED INVENTIONS IN CANADA

There has been a marked trend in the number of patented inventions per capita and in the source of these inventions during this century. Most evident have been the decline in per capita inventiveness since the early 1920's and the shift in importance from the independent to the corporate inventors as a source of patented inventions. This chapter traces the changes that have occurred and discusses some hypotheses that have been advanced to explain similar phenomena in the United States, as well as examining Canadian influencing factors.

The Data

Since this study is examining Canadian output and sources of invention, it was necessary to collect the data in such a manner that it would most accurately and completely reflect the output of Canadian inventors. As was shown in the last chapter, patent information is the best source presently available for obtaining the desired information. Although the Annual Reports of the Patent Commissioner con-

tain information along the lines of that which was desired, it was based on the residence of the patentee. It was felt that this did not accurately reflect the output of Canadian inventors; for example, an invention by an American parent firm could be patented in Canada by its Canadian subsidiary. In the Annual Reports, this would appear as a patent granted to a Canadian resident, but it is not the work of a Canadian inventor. This situation and its direct opposite occurred frequently enough to make the use of the data in the Annual Reports hazardous. As a consequence, the Patent Gazette was the only remaining source which could be used without encountering the same difficulties. The formula that was adopted for getting the desired information from the Patent Gazette appears in Appendix I.

The patent statistics gathered from the Patent Gazette are given in Table 1 and Chart 1. The unavailability of the Patent Gazette for some years and the length of time it took to generate the data prevented the construction of a complete time series. The statistics are presented in terms of the source of the invention, the three sources being independent inventors, corporate inventors and government inventors.

While using these statistics on patented inventions, it is important to recognize that there are two lags involved in the data. Since one of the functions of this chapter is to discuss the possible influences on the output of inventions

TABLE 1

CANADIAN OUTPUT OF INVENTIONS BY SOURCE
AS MEASURED BY PATENTS ISSUED
1901 - 1969[a]

Year	Independent	Corporate	Government	Total
1901	659	40	0	699
1902-1910	--[b]	--	--	--
1911	1034	87	0	1121
1912	1069 1/3	90 1/3	0	1159 2/3
1913	--	--	--	--
1914	1150 1/3	89	0	1239 1/3
1915	1067 1/2	107	0	1174 1/2
1916	990	64 5/6	0	1054 5/6
1917	869 1/2	72	1	942 1/2
1918	870 1/2	75	1	946 1/2
1919	1045	89	0	1134
1920	1532 1/2	114 5/6	1	1648 1/3
1921	1203 1/2	82	0	1285 1/2
1922	1749 1/2	196 1/2	2	1948
1923	1339 1/3	161	1	1501 1/3
1924	1248 1/2	158 2/3	1	1408 1/6
1925	1017 1/6	158 1/2	1	1176 2/3

TABLE 1, -continued

Year	Independent	Corporate	Government	Total
1926	1070 3/5	174 1/2	0	1245 1/10
1927	1064 2/3	180 1/2	0	1245 1/6
1928	1121 2/3	162 2/3	2	1286 1/3
1929	1010 1/2	221 5/6	1	1233 1/3
1930	902	168 1/4	1	1071 1/4
1931	--	--	--	--
1932	734 5/6	240 5/6	0	975 2/3
1933	729 1/2	226	1	956 1/2
1934	685	209 5/6	0	894 5/6
1935	--	--	--	--
1936	549 1/2	154	2	705 1/2
1937	--	--	--	--
1938	483	148	3	634
1939	--	--	--	--
1940	436 1/3	141	1	578 1/3
1941	--	--	--	--
1942	379	148	4	531
1943	330 1/3	101	4 1/2	435 5/6
1944	331 1/3	135 1/2	8 1/2	475 1/3
1945	--	--	--	--
1946	366 1/2	113 1/2	6	486

TABLE 1, -continued

Year	Independent	Corporate	Government	Total
1947	--	--	--	--
1948	428 1/2	125 1/2	5	559
1949	--	--	--	--
1950	473	163 3/4	7	643 3/4
1951	498	163	4	665
1952	--	--	--	--
1953	402	243	13	658
1954	319 1/2	188 5/6	6	514 1/3
1955	--	--	--	--
1956	405	295 2/3	25 1/2	726 1/6
1957	398	307 1/4	31	736 1/4
1958	426 1/4	366 2/3	54	846 11/12
1959	--	--	--	--
1960	559	624 2/3	70 2/3	1254 1/3
1961	--	--	--	--
1962	569 5/6	598 2/3	52	1220 1/2
1963	446 1/2	532 7/12	37 1/2	1016 7/12
1964	492 1/4	568 3/4	39	1100
1965	--	--	--	--
1966	472 1/2	692	61 5/6	1226 1/3

TABLE 1, -continued

Year	Independent	Corporate	Government	Total
1967	--	--	--	--
1968	--	--	--	--
1969	458	$841^{1}/3$	85	$1384^{1}/3$

Source: Gathered from the Canadian Patent Gazette, 1901 - 1969.

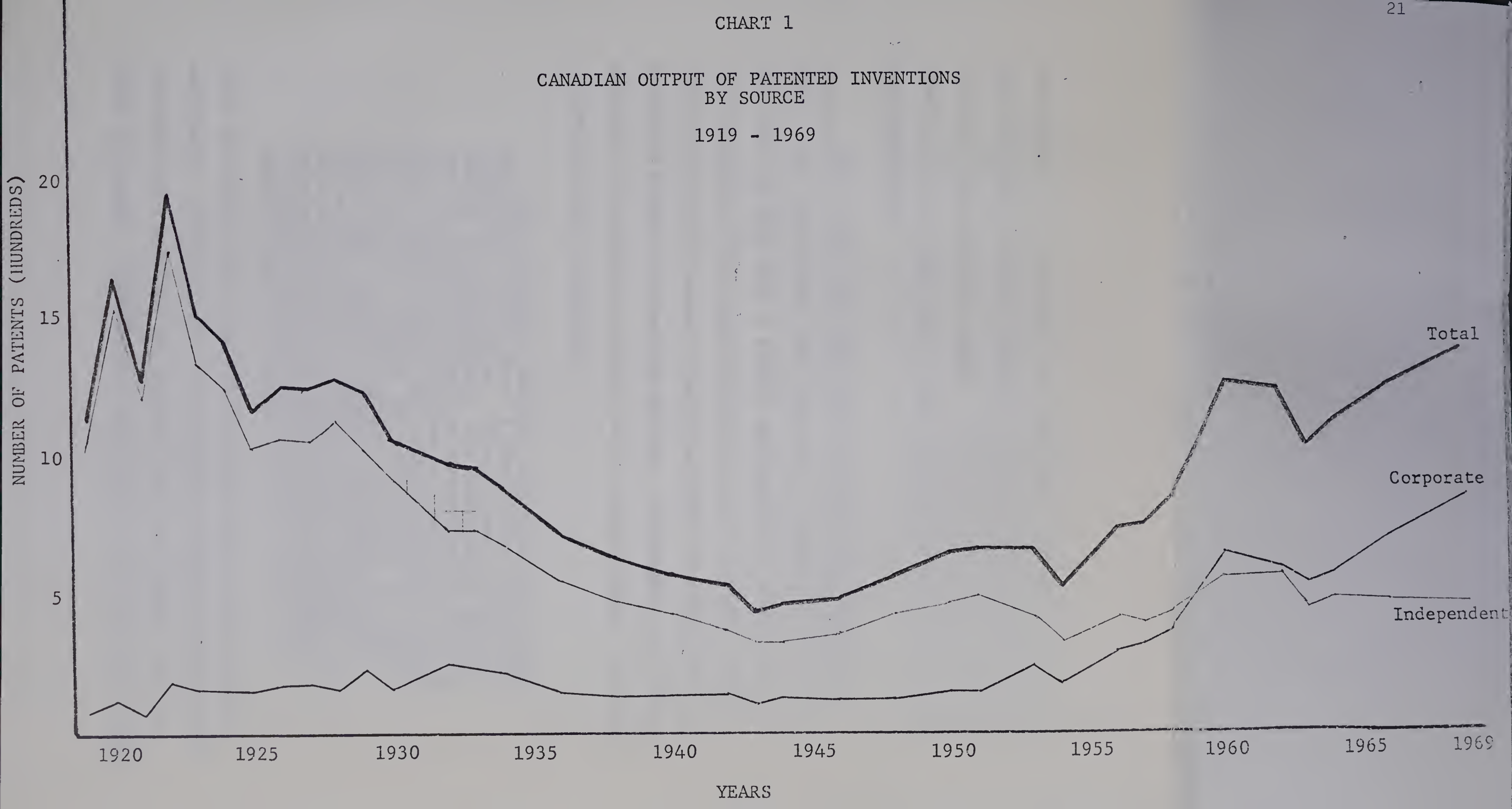
[a] Includes the Yukon and North West Territories, and Newfoundland prior to 1949.

[b] Data not available for these years.

CHART 1

CANADIAN OUTPUT OF PATENTED INVENTIONS
BY SOURCE

1919 - 1969



in Canada, it is necessary to take these lags into consideration in order to better pinpoint the time period when the activity on the inventions began. If this can be done, then the general factors which act to spur invention can be more readily determined.

One of the lags that must be taken into consideration is the lag between the time work is started on an invention and the time when a patent application is taken out for the invention. The length of this lag is, of course, difficult to determine because inventions differ in complexity and inventors differ in inventive ability. Schmookler, in his examination of inventive activity in the United States, was able to develop such an estimate.

> . . .the inventive activity reflected by a patent application began about a year or two before the application was filed. This estimate is based on several considerations. For independent inventors the mean duration from conception of the original invention to reduction to patentable form is about twenty months; for captive inventors, about nine months. Because the distribution is skewed, the median and modal values are lower. On the other hand, patent attorneys customarily need a few months to have a search of the literature made to determine the advisability of filing and to prepare the application, and the inventions of captive inventors are frequently tested commercial prior to filing.[1]

While this gives some indication of the lag, it must be used cautiously. First of all, it is only an estimate and the error involved would probably be large if the same figures were applied to Canada. Undoubtedly, the length of the lag will differ

according to the source of the invention, but there will also be interindustry and intertemporal differences. Unless the industrial compositions of Canada and the U. S. were the same, then there would certainly be a difference in the average lag. In addition, the permissible period of use prior to patenting is two years in Canada and only one year in the United States. Therefore, while these estimates have many faults for use in Canada, they are the only estimates available.

The other lag is the lag between the time a patent is applied for and the time when it is granted. The most significant factor that contributes to the lag is the ability of the patent office to process patent applications. This would depend on the size of the staff and the relative amount of expertise they had. As these may change over time, so may the average lag.

In order to get an indication of the size of the lag between the application for a patent and its issuance, a small sample of twenty observations was taken every five years, where the Patent Gazette was available. Each sample of twenty was divided equally between independent and corporate inventors. The results of the sample are given in Table 2. Because of the small size of the sample, the results should be interpreted to be no more than a rough approximation.

TABLE 2

APPLICATION - ISSUANCE LAG
IN MONTHS

Year	Independent Class		Corporate Class	
	Mean	Median	Mean	Median
1901	4.7	2.5	8.9	6.5
1911	4.1	4.0	12.6	10.0
1916	6.1	4.5	25.4	19.5
1921	8.9	9.0	9.6	10.0
1926	13.8	12.5	16.1	11.0
1931	12.0	12.0	23.2	21.5
1936	13.6	9.5	13.7	13.0
1941	19.8	19.0	29.0	27.0
1946	21.0	17.5	37.4	30.5
1951	39.0	37.0	41.7	37.5
1956	44.8	42.5	87.1	37.5
1966	30.9	32.0	44.4	36.5

The results are given in the terms of the mean and median. The median has been included because it is less influenced by extreme values than the mean.

independent inventions and corporate inventions have increased through time. The application issuance lag for corporate inventions in 1956 seems to be inordinately high. The fact that there was also an increase in the lag for independent inventions suggests that there was likely an increase in the lag for corporate inventions, but the size of the increase for the latter suggests that the sample was one that contained inordinately high values.

Therefore, combining the first lag described, which shall be called the inventive lag, with the application-issuance lag would give a rough idea of the time which had elapsed between the start of work on an invention and when it was issued a patent. When interpreting the results obtained by the use of these lags, one must be cognizant of the fact that while the lags are not a completely accurate measurement, they are more useful than cavalier hypotheses. Hopefully, by applying this total lag to the patents issued in any given year, the approximate period in which the inventions were begun may be determined; as a consequence, the factors that may have been conducive to the creation of the inventions are more readily discernible.

Short Run

There are two different ways to approach the problem of trends in inventing. The usual method is to ex-

amine the long run per capita trend, and this will be done in the next section. A less frequently used approach is to examine short-run movements in patented inventions. However, this latter approach can be highly informative in outlining some of the factors which affect inventive activity at a given time. In this section, the Gross National Product and Industrial Production will be examined as factors influencing the output of inventions.

Stafford has hypothesized that there are three types of cycles in inventing in existence at any one time; ". . .the course of invention may represent a mixture of 'very long cycles' (several centuries), 'long cycles' (less than a century, and 'short' ones corresponding to those of the business cycle."[2] It is to the last of these to which this section is directed. On the surface, there would seem to be a relationship between the output of inventions and the business cycle, since financing plays an important part in inventive activity, especially in the corporate sector. However, financing is also important for the independent inventor, not only to pay for the cost of equipment and materials but also to allow the inventor the time necessary to engage in inventive activity. An unemployed inventor will most likely work on finding another job and not on his invention.

The business cycle is represented here by the

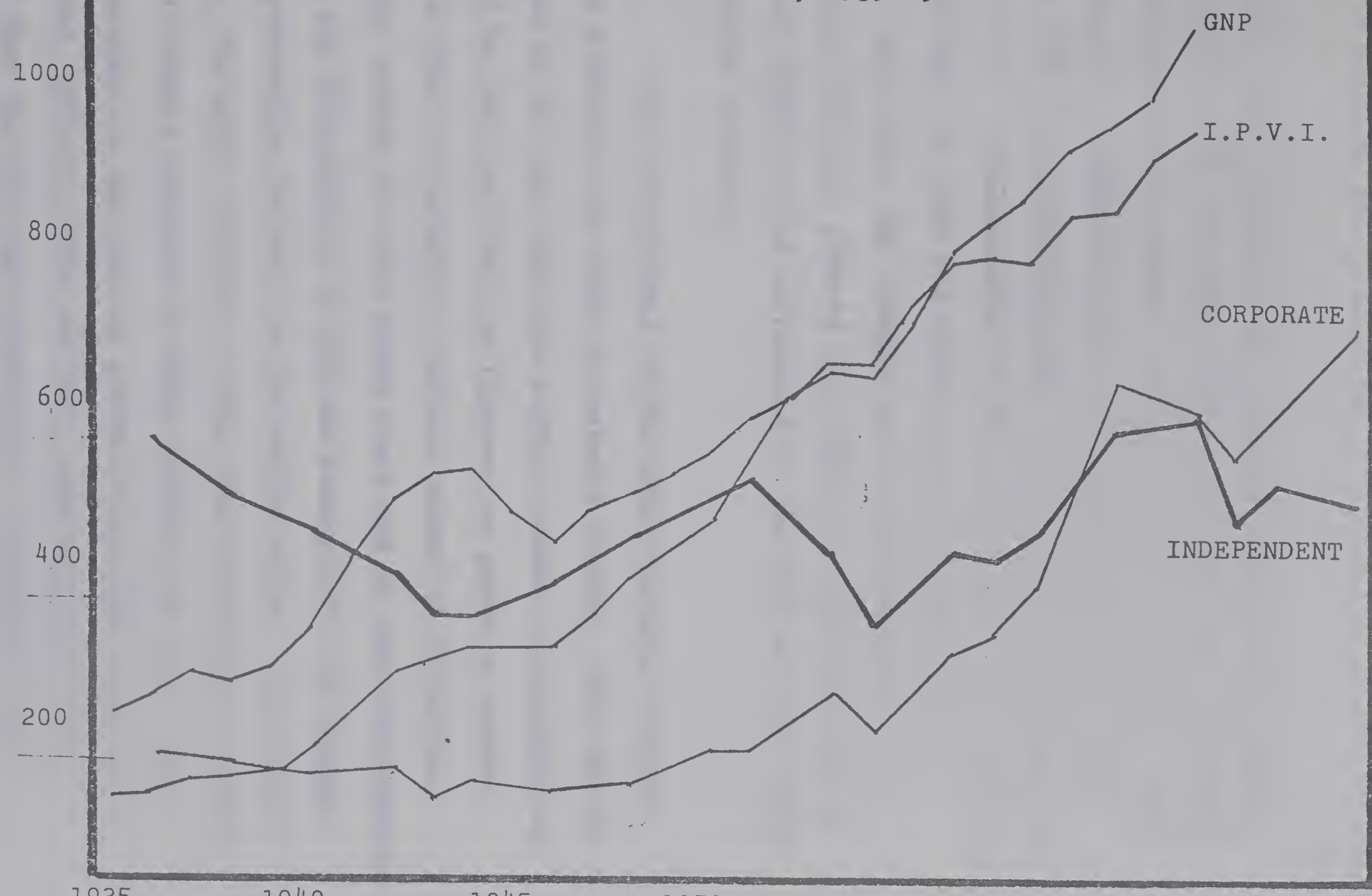
fluctuation in Gross National Production and the Industrial Production Index. The Industrial Production Index is included because it is felt that it is a better representative of the factors that would influence the production of technical inventions than GNP, since the latter includes the service sector. The service sector, by its very nature, is less likely to be a source for invention than the industrial sector. The statistics on the GNP and the Industrial Production Index are included in Tables A and B respectively in Appendix II, and appear in Chart II along with aggregate patented inventions. This data covers the period from 1935 to 1962, which means that the patented inventions from the start of the second World War to 1966 can be examined. Because of the problem of getting reliable statistics on GNP and Industrial Production prior to 1926, the early part of the century has not been included.

As can be seen from Charts I and II, the aggregate number of patented inventions has fluctuated many times since the beginning of the century. Although the time series is not complete, peaks in the total number of patents are evident in 1914, 1920, 1922, 1928, 1951 and 1960. There are troughs in 1917-18, 1921, 1925, 1943, 1954 and 1963. In order to be able to compare these fluctuations with those that appear in the data on GNP and Industrial Production, it is necessary to adjust the appropriate peaks and troughs in

CHART 2

COMPARISON OF G.N.P. AND THE INDUSTRIAL PRODUCTION VOLUME INDEX

WITH PATENTED INVENTIONS FROM CANADIAN INDEPENDENT
AND CORPORATE INVENTORS, 1935-1966



accordance with the sum of the inventive lag and the application-issuance lag, in other words, the total lag. By doing this, the peaks are reached in 1946-47 and in 1955-56. This last figure is reached in part by assuming that the sample for the 1956 application-issuance lag for corporate inventions is not a true representation of the actual lag, and therefore, assuming that the 1960 lag would be at most five years in length. Similarly, the troughs would have occurred at approximately 1939-40, 1948-49 and 1958-59. This last set of peaks and troughs would correspond to the high and low points of inventive activity.

The fluctuations in the Gross National Product are less volatile than those in patents issued. This can be explained by the fact that the service sector is included in GNP, and by the fact that the figures are given at market prices so that it includes a certain amount of inflation. Therefore, except for 1954 where there was an absolute decrease in GNP, the fluctuations in GNP are measured by the changes in the percentage increase in its dollar value. In addition to 1954, the major slowdowns in the rate of increase in Gross National Product occurred in 1938, 1945-46 and 1958. The major increase in the rate of growth of the GNP occurred in 1942, 1948, 1951-52, 1956 and 1962, each increase being smaller than the one that preceded it. Comparing these changes with the fluctuations in inventive activity, as meas-

ured by patents issued adjusted for the total lag, it can be seen that the direction and timing of changes in both follow fairly well except for the period during the war and slightly after it. Thus, the peak in inventive activity in about 1955-56 leads slightly the rise in GNP in 1956, and troughs in 1939-40 and 1958-59 lag slightly behind the decreases in the rate of growth in GNP in 1938 and 1958. The fact that the time series on patented inventions is not complete prevents a thorough comparison of all fluctuations; for example, the 1942 increase in the rate of growth of GNP. The period from 1941 to 1950 provides problems. The peak in inventive activity in 1946-47 falls at the end of the 1944-46 period of slowdown in the growth of GNP. Similarly, the trough in inventive activity in 1948-49 falls at the end of the 1948 increase in the growth of GNP. I believe, however, that these two conflicts can be explained satisfactorily. It seems reasonable to expect that a great deal of knowledge was gained during the war years which was adopted after the war to Canadian problems. This would account for the increase in inventive activity immediately following the war. It also seems that following this spurt of inventive activity there was a return to more normal pattern of inventive activity which would account for the drop in inventive activity in 1948-49. By examining Chart I, and introducing the total lag, it can be seen that the same type of thing occurred after World War I. As Caves and Holton stated:

> The nasty truth remains, however, that World War I advanced Canada's industrial facilities and skills in ways which would have taken much longer under normal peace time stimuli.
>
> World War II brought the same sort of changes to the Canadian economy as did its grim predecessor. . .The Department of Reconstruction and Supply estimated that roughly two-thirds of the special wartime industry structure was adaptable to peace-time uses, and the reversion was quickly accomplished by the end of 1947.[3]

The timing and fluctuations in the Industrial Production Index coincide with changes in Gross National Production, although the former suffers absolute declines in 1945-46 and in 1958 where the latter has only a slowdown in the rate of growth. Therefore, the comparison of inventive activity with GNP would be the same as a comparison of inventive activity with the Industrial Production Index. However, the size of the declines in the Industrial Production Index seem to explain better the size of the declines in inventive activity. This is especially true of the decline in patented inventions in 1954 and 1963, matching decline in industrial production in 1945-46, and the slowdown and decline in 1956-58.

Therefore, to summarize the results of this section, it appears that during peacetime, the production of inventions is influenced by the business cycle. This has been seen in the close relationship between the turning points in the growth rate of the Gross National Product and the turning points in the level of inventive activity. Also, it appears that industrial production has a direct influence on the amount

of inventive activity occurring at a given time. These conclusions depend heavily on the accuracy of the lags involved in determining the start of inventive activity. While patents issued may not be the best measure of inventive activity, they are highly related to the level of successful inventive activity.

Long Run

The customary approach used to examine trends in patented inventions is to investigate the long run per capita tendency. Much of the important work in this area has been done in the United States by scholars such as S. C. Gilfillan, Alfred B. Stafford, Barkev Sanders, Jacob Schmookler, and Frederic M. Scherer, to name but a few. These scholars have reported a decline in patents issued per capita during this century in the U. S., and have often used Canada as an example of another developed country that has suffered a similar decline. The purpose of this section is to examine the nature of the decline in patented inventions per capita in Canada and to discuss some of the possible reasons for the decline.

The data on patented inventions per capita appears in Table 3 and Chart 3. The statistics on patented inventions per capita by source are also included in the same table and chart; note that inventions per capita by the gov-

TABLE 3

PATENTED INVENTIONS PER 10,000 OF POPULATION
BY SOURCE
1901 - 1969

Year	Independent	Corporate	Total[a]
1901	1.23	0.07	1.30
1902-1910	--[b]	--	--
1911	1.43	0.12	1.56
1912	1.45	0.12	1.57
1913	--	--	--
1914	1.46	0.11	1.57
1915	1.34	0.13	1.47
1916	1.24	0.08	1.32
1917	1.08	0.09	1.17
1918	1.07	0.09	1.16
1919	1.26	0.11	1.36
1920	1.74	0.13	1.88
1921	1.37	0.09	1.46
1922	1.96	0.22	2.18
1923	1.49	0.18	1.67
1924	1.37	0.17	1.54
1925	1.09	0.17	1.27
1926	1.13	0.18	1.32
1927	1.10	0.19	1.29

TABLE 3
(Continued)

Year	Independent	Corporate	Total[a]
1928	1.14	0.17	1.31
1929	1.01	0.22	1.23
1930	0.88	0.16	1.05
1931	--	--	--
1932	0.70	0.23	0.93
1933	0.68	0.21	0.90
1934	0.63	0.19	0.83
1935	--	--	--
1936	0.49	0.14	0.64
1937	--	--	--
1938	0.43	0.13	0.57
1939	--	--	--
1940	0.38	0.12	0.51
1941	--	--	--
1942	0.33	0.13	0.46
1943	0.28	0.09	0.37
1944	0.28	0.11	0.40
1945	--	--	--
1946	0.30	0.09	0.40
1947	--	--	--
1948	0.33	0.10	0.44
1949	--	--	--

TABLE 3
(Continued)

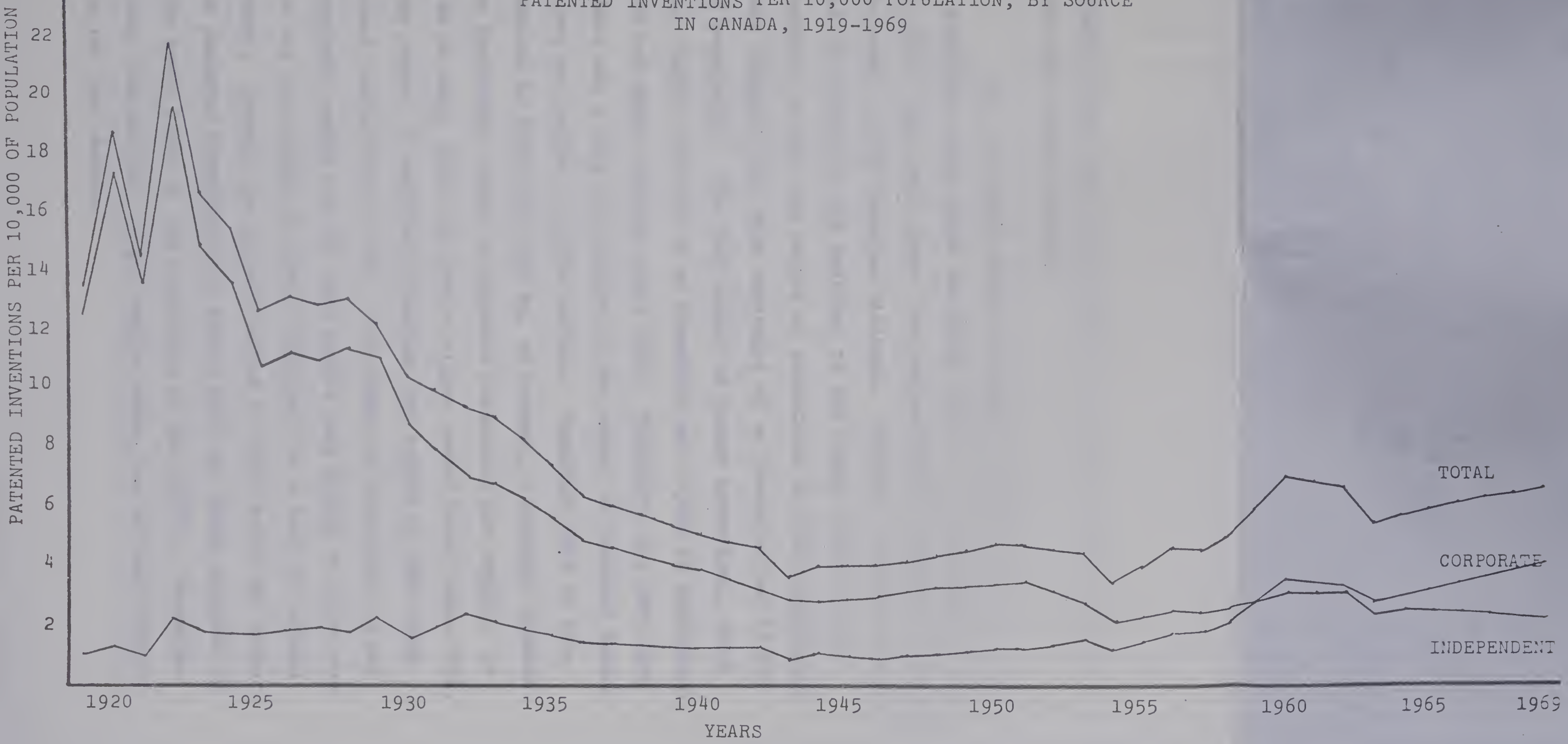
Year	Independent	Corporate	Total[a]
1950	0.34	0.12	0.47
1951	0.36	0.12	0.47
1952	--	--	--
1953	0.27	0.16	0.44
1954	0.21	0.12	0.34
1955	--	--	--
1956	0.25	0.18	0.45
1957	0.24	0.18	0.44
1958	0.25	0.21	0.50
1959	--	--	--
1960	0.31	0.35	0.70
1961	--	--	--
1962	0.31	0.32	0.65
1963	0.24	0.28	0.54
1964	0.26	0.29	0.57
1965	--	--	--
1966	0.24	0.35	0.61
1967	--	--	--
1968	--	--	--
1969	0.22	0.40	0.66

SOURCE:
Invention statistics have been taken from TABLE 1, and population statistics from the Canada Year Book.

[a] Total refers to Canadian patented inventions from all sources. [b] Data not available for these years.

CHART 3

PATENTED INVENTIONS PER 10,000 POPULATION, BY SOURCE
IN CANADA, 1919-1969



ernment sector are not included as a source, mainly because of the small number involved.

The per capita number of patented inventions has shown a declining trend since the early 1920's. At its highest point in 1922, there were almost two and one-fifth patented inventions for every 10,000 Canadian citizens. However, by 1954, the output of inventions had declined to its lowest level in this century, so that the output of inventions in 1954 represented only slightly more than one-third of an invention per 10,000 of population. The 1940 output of patent inventions, which was roughly one-half of an invention per 10,000 of population, was not again attained until 1958. Therefore, the fact that there was a long run decline in the number of patented inventions per capita is quite obvious. Something that is less obvious is that there may be, at present, a movement towards an increasing number of patented inventions per capita. As can be seen, there has been a slight upward trend since 1954, the number of patented inventions per capita in 1969 being about double that in 1954. The number of inventions is not complete enough nor the time period long enough to allow one to say for certain if there definitely is a long run upward trend. Indeed, the present output is still below the output of patented inventions per capita that was being achieved in the early years of the depression of the 1930's. Nevertheless, the decline, in per capita terms, has at least abated in the last decade.

In order to find the source of the decline, it is necessary to examine the output of the independent and corporate inventors in Canada. In per capita terms, the independent inventor has been the major source for the decline in patented inventions. Patented inventions from this source have declined from 1.96 per 10,000 in 1922 to a base of 0.21 in 1954, or to only about 11% of the 1922 level. The fact that the 1969 level of patented inventions per 10,000 was only 0.22 provides no promise that there will be any change in this downward trend in inventions from independent inventors.

The trend in corporate invention has been much different from independent invention. In the early part of the century, the corporate inventor was a much less important source of invention than the independent inventor. Through the 1920's, the output of corporate inventors grew while that of independent inventors stagnated. After reaching an output of 0.23 patented inventions per 10,000 in 1932, the number of inventions coming from corporate inventors declined through the rest of the 1930's and 1940's. However, since the early 1950's, the total number of patented inventions from the corporate sector have increased. By 1960, corporate inventors had surpassed the faltering independent inventors as the major source of patented inventions. The rise in the per capita output of patented inventions in the 1960's can be attributed

to the rise in the output of patented inventions of the corporate inventors which has been large enough to outweigh the decline in output of the independent inventors.

Many hypotheses have been developed in order to explain the overall decline in patented inventions in other centuries, especially in the United States. Since some of these hypotheses help to explain the decline in Canada, they will be repeated and discussed. The hypotheses concerning the decline in patented inventions fall into two areas; hypotheses concerning a decline in inventiveness, and hypotheses dealing with a decline in the patenting of inventions. Many of the reasons given for a decline in the patenting of inventions were presented in the second chapter in discussing the shortcomings of patents as an index of invention. The most important hypotheses for such a decline will be repeated. But there is, I think, one statement which sums up the problem quite well.

> In the light of the recent inventive trends, a certain conceptual difficulty is posed. This comes from the tendency to think of technical change in two dimensions, that is, some single quantitative index of the rate of invention versus the time scale. Technological change is thus portrayed or conceived as being a moment on a two-dimensional plane, the assumption being that units of technical change are homogeneous and independent of time. We have shown, however, that invention is growing more complex in principles, means, functions and source (individual or group); so that, whatever the units may stand for, they are not homogeneous in time. Thus, while a measure of volume (number of Patents) may be falling as at present, an index of complexity as well as other possible indexes of invention which are not obvious

> to us at the moment may be moving in opposite or diverse directions. . .no single index may be adequate for the correct delineation of changes in the inventive process.[4]

The first hypothesis is that there has been an upgrading in those inventions that are patented, especially by corporations. Barkev Sanders reported that utilization studies of assigned patents showed tendencies toward a larger percentage of patented inventions coming into use in the United States as well as in Germany, Sweden and Great Britain.[5] The reason given for the upgrading of inventions is commercial testing of inventions prior to applying for a patent; those inventions which were not commercially feasible would not be patented. There is little reason not to assume that the same is true in Canada, since very many corporations are foreign-controlled and especially American-controlled, and since the number of patents granted to corporations now is larger than the number granted to individuals. A second reason given for the decline in patenting in the United States was an increase in the desire for secrecy. This was due to the decrease in the protection afforded by a patent as a result of such governmental and judicial procedures as compulsory licensing. This sort of pressure has not occurred in Canada where compulsory licensing and the invalidating of patents occurs infrequently. However, since many Canadian corporations are American subsidiaries, they are likely holding secret inventions that are related to those that are held secret in the United States, and may be

holding secret other inventions which are not related to the American operations because of orders from the parent company. Both of these explanations are directed mainly at the corporations, but since 1946, the number of patents granted to corporations has jumped from $113^{1}/2$ in 1946 to $841^{1}/3$ in 1959. Therefore, if both of the arguments given are valid, then the amount of invention by the corporation class has grown at an even steeper rate than is evident in the patent statistics.
A third argument for a decline in patenting is that the standards for determining an invention by the Patent Office have increased. This would have meant denying patents to questionable inventions much more frequently and would have undoubtedly affected individual inventors much more than corporate inventors. This would perhaps account for some of the decline in the number of patents granted to individuals. Statistics on the number of patent applications from the independent inventors would have been useful in assessing how significant such a procedure may have been.

There are also several hypotheses that deal with a decline in inventiveness. One of these has already been mentioned, and that is that invention runs in cycles. The shorter cycles are at least partially explained by the fact that they seem to follow the business cycle. The longer cycles are not as easily explained but it may be they are influenced by scientific discovery. If this is the case, then a period of scientific discovery would increase the knowledge base

for society. Although all discoveries do not lend themselves to invention as, for example, a new atom with an extremely short half-life, those that do will lead to a few inventions and the combination of discovery and invention to a few more inventions. Eventually, the number of inventions will decline after the most obvious have been found. Unless there are more discoveries that lend themselves to inventions, then the decline will continue. In this way, the number of inventions that are appearing may be following a cycle. Unfortunately, this hypothesis is untested. A second hypothesis, which is related to the above hypothesis, is that the process of invention has become more complex and this has led to a larger relative input than in earlier history. This hypothesis is related to the last, for if, indeed, the decline of inventiveness is because the more obvious inventions have been discovered, given the state of society's technical knowledge, then it will take more resources and man-hours to get further inventions. It may also be true that the composition or form of our knowledge has changed radically enough that our systems of education have not been able to cope, thus necessitating a larger input until our society can get caught up. Another possibility still is that the needs of our society have changed so quickly that our technology has not been able to keep up, and this has lengthened the time-span needed to develop inventions which solve these needs.

There were several hypotheses presented by Gilfillan in 1935 for the United States, but whose effect is questionable.[6] What effect they may have had is unknown. One of these is that the standardization which accompanies big business is a force to discourage inventions that contravene their standards. Along with this hypothesis goes the hypothesis that the growth of fixed capital is an anti-inventive force, as too rapid obsolence would hurt profits. This would seem to be true only with those inventions which would be of minor importance. The third hypothesis was attributed to a claim of Rossman and Olken that engineers were taught in the schools to abhor the name inventor, to regard too highly engineering tradition and the supposed voice of authority, to shun especially fundamental invention, normally out of their line, and to seek to make familiar things better, not radically different; this outlook was likely to be fostered by the corporation.[7] This list of hypotheses for the decline in inventiveness is not complete, but it gives an indication of how scholars have attempted to explain the decline.

While some, if not most, of these hypotheses would be useful in describing why there were not more patented inventions than those that were recorded, they are, in general, not overly helpful in telling us why the number of patented inventions declined in Canada. This is because they deal, in the main, with the decreases in the corporate sector, while the

source of decline in Canada was basically the independent inventor. Therefore, it is necessary to look for additional possible explanations for the decline in the output in patented inventions. The most obvious explanation of the decline in the number of patented inventions through the 1930's and 1940's is that abnormally depressing social and economic conditions are not generally conducive to inventive activity. However, it is the failure of the output of the individual inventor to rise after World War II that leaves the most unanswered questions.

One line of argument directed towards this problem is that cost of inventing has increased, and that the individual does not possess the financial means to test out his ideas. It is also suggested that the individual is not highly enough trained to bring modern knowledge to bear upon his tasks, and that he lacks contact with like-minded workers and the stimulus arising from such co-operation.[8] The Sources of Invention tries to provide an argument against such hypotheses through examples of important inventions that have occurred in spite of these obstacles, which only proves that many inventors are highly resourceful and intelligent. Also, the fact is that there are more engineers, scientists and other highly skilled and trained people living now than ever before who, through professional bodies and other groups, are able to meet like-minded workers and to get the stimulus arising from

such co-operation. This suggests that these hypotheses may be going in the wrong direction. Perhaps the problem is over-training as suggested before, that these people are inadvertantly trained not to look beyond their narrow technical training and that these skilled people approach problems in a different way than the important inventors of the past; that is, that there has been a psychological change in the process of invention. Here again, though, such an explanation leaves one feeling uncomfortable. There is one hypothesis that is more readily acceptable. It is suggested that research institutions and departments are absorbing many of the scientific and inventive minds that would have otherwise produced inventions which would have fallen into the Independent Class. A corollary to this is a larger percentage of the population is now working for someone other than themselves than was the case earlier in the century. Since many companies hire employees under contracts which state that the company receives all inventions pertaining to their jobs, that the employees make while they are working for the company, and since most inventors produce inventions that are directly related to the field in which they work, many inventions that would have appeared as independent inventions earlier in the century, are now appearing as corporate inventions. Also, it is suggested that because of the advantages of the corporation as a form of business organization, that inventions which earlier might have been granted non-incorporated business are now being is-

sued to corporations.[9] A fourth possibility is that corporations may be more actively engaged in buying up inventions and then patenting them under the corporate name. Thus, not only may there be some change in the inventiveness and in the attitude toward patenting inventions by individuals, but also there may be a basic change in the manner in which inventions are appearing in the Patent Gazette.

One further explanation for the decline in patented inventions is that the structure of the economy has changed radically. The service sector in Canada, at present, contributes much more to GNP and employs many more people now than it did in the early part of the century. The people employed in the service sector likely produce less inventions than, for example, people employed in manufacturing industries; this would be mainly because of a difference in educational background.

As a final note in this section, an attempt was made to find out if there was any advantage to using the civilian labour force, instead of population, to measure the inventiveness of Canadians. The rationale for this was that the rapid growth of Canada's population, especially since World War II, might have meant that there was a larger segment of the population, in the post-war era, who were too young to be considered inventors than in earlier periods. The results appear in Table C in Appendix II. While there were a few

small differences, using the labour force instead of population, aside from higher values which were expected, the timing of peaks and troughs and the relative magnitude of the changes were generally the same.

Research and Development Expenditure

In the last section, the rapid growth in the output of patented inventions by corporate inventors during the 1950's and 1960's was pointed out. In this section, an investigation of research and development expenditures will be made in order to gain more information about the form and reasons for this increased production of inventions.

In 1950, corporate inventors patented $163^{3}/4$ inventions. By 1969, corporate inventors were responsible for $841^{1}/3$ patented inventions. The per capita figures demonstrate a rise in 1969.

One of the factors which partly explains this growth in patented inventions is a change in the environment in which Canadian industry functions. J.J. Brown, in his historical study of important Canadian inventions, demonstrated that industrial research was at a very low level between the first and second World Wars, and the reason for this, he said, could be traced partly to the depression which made it difficult to maintain operations, let alone put extra money into research laboratories.[10] Protectionism since the war has been decreasing by giving way to freer trade policies, and business conditions have improved tremendously. As an in-

dication of the latter, the Gross National Product at market prices has grown from almost twelve billion dollars in 1946 to over sixty-one billion dollars in 1966, or in other words, it has grown to over five times larger than the 1946 level in twenty years.[11] In addition, the Second World War seemed to act as a stimulus to Canadian economy.

> Expansion of productive capacity in manufacturing was particularly striking in such fields as tool making, electrical apparatus, chemicals and aluminum. . . Entire new industries were created, making for example, roller bearings, magnesium and artificial rubber. . . Advances were made in the production of finished goods and equipment, some of which were of a type quite new to Canadian industry and which had previously been imported, such as optical glass, high octane gasoline, penicillin and sulfa drugs.[12]

Thus, the business environment in Canada, after the war, was much more favourable than before the war, and this would allow corporations to take a more active role in industrial research.

The explanation for carrying on industrial research and development is that it is an investment. The investment is made in R. and D. for the same reason as it is made in advertising, to maintain a corporation share of the market or to improve its market share. There are many explanations why the risks are taken and large expenditures made. Scherer has compiled a list of theoretical explanations and succeeded in getting evidence which supports most of them in Patents and the Corporation.[13] The main ingredients of the theoret-

ical list are the following:

1. R. and D. expenditures may be undertaken simply to be able to remain in business, especially where companies, constituting an industry, are engaged in a vigorous technological race and when competitors are unwilling to share their new developments by licensing.

2. Exclusive patent control over a superior product provides a monopoly situation which allows a firm to choose the price and output which will maximize its profits.

3. The royalties available from licensing a patented invention, especially by a technological leader, are a form of income and may defer the costs and risks involved in engaging in Research and Development.

4. A firm may be able to derive monopolistic rewards from technological advance by exploiting the fact of its technological leadership. Thus, a firm can benefit greatly in prestige by being the first on the market with a new product, or can enjoy a good deal of control over the price of its products because its owners believe the company is the technological leader in its field. This is, then, one method that can be used to achieve product differentiation.

5. Another competitive advantage which the inventor can enjoy is the possession of "know-how". This firm will almost always benefit by being first with an innovation.

Therefore, what these basically come down to is that expenditures in R. and D. may allow a corporation to make greater profits than it would otherwise make by making its markets more secure.

Statistics on Research and Development expenditures in Canada have only been published biennially by D. B. S. since 1956. These statistics, however, are quite revealing.

TABLE 4

SUMMARY OF R. AND D. EXPENDITURES
BY CANADIAN FIRMS
1955 - 1965

Year	Current Expenditures in Canada			Capital Expenditures	Number of Reporting Companies
	Intramural	Extramural	Total		
	(000,000)				
1955	51.4	1.9	53.3	--	377
1957	124.5	4.2	128.7	12.6	455
1959	96.6	3.3	99.9	10.7	471
1961	114.0	4.3	115.9	13.5	523
1963	153.6	5.6	155.0	27.7	701
1964	188.3	6.6	188.9	46.5	--
1965	235.0	9.4	237.2	49.9	825

Source: D. B. S., Industrial Research and Development Expenditure in Canada (1965), 14.

As Table 4 shows, there has been a large dollar increase in spending on both current R. and D. work and on physical capital. But perhaps more interesting is the increase in the number of companies who have reported being engaged in Research and Development. However, these numbers of reporting companies are a bit deceiving as can be seen in Table 5

on the concentration of R. and D. spending.

TABLE 5

CONCENTRATION OF INDUSTRIAL
R. AND D. EXPENDITURES
1965

Companies Ranked by Size of Current Intra-Mural Expenditures	5	10	25	50	100	200
Percentage of Total Current Intra-Mural Expenditures	33.9	44.9	62.8	75.3	86.2	93.8

Source: Same as Table 4, p. 15.

Thus, only thirteen companies accounted for approximately one-half of the total current intra-mural expenditures in 1965. The importance of these companies can be witnessed by the fact that the decrease in the 1959 current intra-mural expenditures can be attributed to decreases in spending by companies involved in the Transportation Equipment industry alone.

One interesting piece of information given by D. B. S. concerns the composition of the expenditure. D. B. S. estimated that of the total current intra-mural expenditures made in 1965, 4% went for basic research, 28% for applied research and 68% for development. Therefore, as has been hypothesized before, most of the work done by a corporate Research and Dev-

elopment department is not directed towards the production of inventions, although undoubtedly part of the expenditure for development may lead to some inventions which are related to the inventions that are being developed.

Although some possible reasons for corporations involving themselves in R. and D. have already been cited, they do not completely explain the large increase in such activity in Canada since the war. Trying to produce inventions is a risky proposition since there is no prior predictability as to when, how, or in what shape an invention will be made. The introduction of Federal Government tax incentives, since they would reduce the potential losses involved in taking these risks, have been a factor contributing to the growth in R. and D. expenditures, and therefore have contributed to the increased output of corporate inventions.

> Since 1944, companies operating in Canada have been allowed to deduct a portion of their expenditures on 'scientific research' activities from their taxable incomes. The rules governing the eligible portion were changed from time to time and by 1962 had reached 100 per cent of all current and capital expenditures.[14]

In addition to this program, a general incentive program for R. and D. expenditures was incorporated into the tax structure in 1962.

> Under this program, corporations were allowed to deduct a further 50 per cent of all expenditures in Canada which exceed their expenditures in the 1961 base period and which were allowable under

> the definition and the other relevant provision of the Act. This programme is effective for the taxation years 1962 through 1966.
> . . . It's principal aims were to increase industrial R. and D. expenditures and the emphasize the vital importance of research activities performed 'in-house' or under contract in Canada for the maintenance and development of production and competitive capabilities. . . It was also intended to strengthen the R. and D. capabilities of some Canadian companies in relation to the research activities of their affiliated companies abroad.[15]

Referring again to Table 4, the growth of current expenditures and especially the growth in capital expenditures and in the number of reporting companies seem clear indication of the success of these incentive programs in meeting their aims. These programs also appear to be one of the more important factors leading to an increased number of patented inventions coming from the corporate sector in the 1960's.

Regional Output of Patented Inventions

This final section of the chapter is a further attempt to dissect the characteristics of patented inventions in Canada, It is a cross-sectional analysis of the trends in the output of inventions for five areas of Canada, British Columbia, the Prairie provinces and the "North", Ontario, Quebec and the Maritimes.

The statistics on the regional breakdown by the source of the patented inventions appears in Table 6. The data was collected for four years, 1901, 1926, 1951 and 1969. Since

TABLE 6

REGIONAL BREAKDOWN OF PATENTED INVENTIONS BY SOURCE

Year	Region	Independent	Corporate	Government	Total
1901	British Columbia	58	0	0	58
	Prairies & North	53.3	0	0	53.3
	Ontario	348.5	29	0	377.5
	Quebec	162.5	9	0	171.2
	Maritimes	37	2	0	39
1926	British Columbia	122	11.5	0	133.5
	Prairies & North	239	10	0	249
	Ontario	426.1	98.5	0	524.6
	Quebec	233	54.5	0	287.5
	Maritimes	50.5	0	0	50.5
1951	British Columbia	58.5	8	0	66.5
	Prairies & North	110	13	0	123
	Ontario	167.5	72.5	3.5	243.5
	Quebec	144	66.5	0	210.5
	Maritimes	18	3	.5	21.5
1969	British Columbia	60.5	65.3	4	129.8
	Prairies & North	71	58.8	5.5	135.3
	Ontario	200.5	453.3	64.2	718
	Quebec	122	259.5	9	390.5
	Maritimes	4	3.5	2.3	9.7

Source: Gathered from Canadian Patent Gazette

Manitoba was the only Prairie province which had entered Confederation in 1901, there was a problem in collecting data for this year. In order to keep the data consistent, and since it was felt that inventors in what are now Alberta and Saskatchewan would likely patent these inventions in "Canada", patents granted to inventors from the North West Territories and, also, the Yukon were included in 1901 and through the later years. This, it was felt, would get around the problem and this is why the region "Prairies and North" appears as it does. For similar reasons, Newfoundland is included in the statistics for the Maritimes. In Table 7 and Chart 4, the per capita figures on total patented inventions per region are presented.

In absolute numbers, Ontario and Quebec have always had more patented inventions than any of the others. Except for 1901, the Prairies have always ranked third, British Columbia fourth, and the Maritimes always fifth. The 1926 figures reflect the large number of patented inventions produced in the twenties; the 1951 figures reflect the decline in patented inventions that was evident until about 1954; and the 1969 figures reflect the resurgence in the total number of patented inventions since 1954. From 1926 to 1969, the decline in the Independent class is evident among all the regions with the number from B. C.

TABLE 7

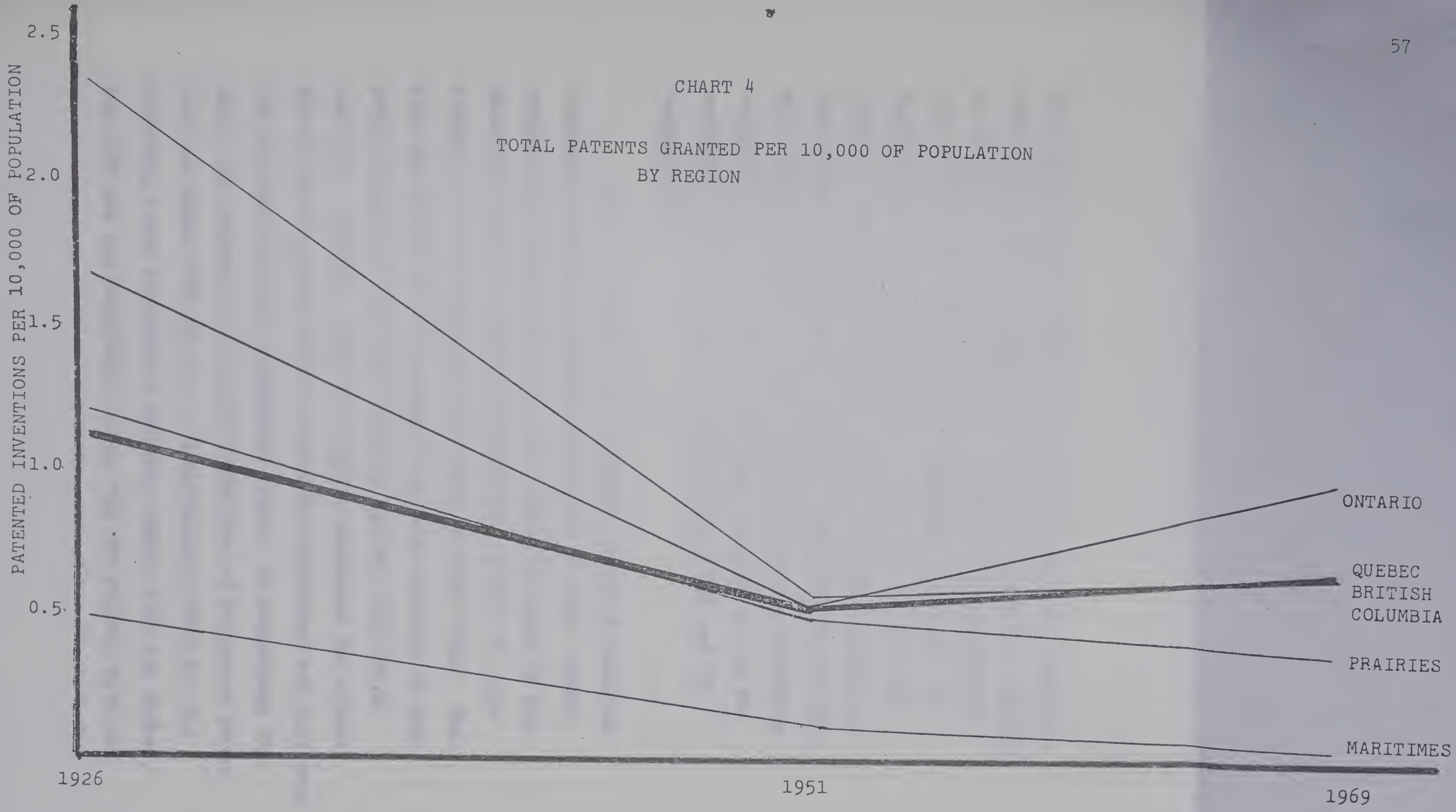
REGIONAL BREAKDOWN OF PATENTED INVENTIONS
PER 10,000 OF POPULATION BY SOURCE

Year	Region	Independent	Corporate	Total
1901	British Columbia	3.25	0	3.25
	Prairies & North	1.14	0	1.14
	Ontario	1.60	0.13	1.73
	Quebec	0.99	0.05	1.04
	Maritimes	0.44	0	0.44
1926	British Columbia	2.15	0.20	2.35
	Prairies & North	1.15	0.05	1.20
	Ontario	1.35	0.32	1.67
	Quebec	0.91	0.21	1.12
	Maritimes	0.49	0	0.49
1951	British Columbia	0.50	0.07	0.57
	Prairies & North	0.43	0.05	0.49
	Ontario	0.36	0.16	0.53
	Quebec	0.36	0.16	0.52
	Maritimes	0.11	0.02	0.13
1969	British Columbia	0.29	0.32	0.63
	Prairies & North	0.20	0.17	0.38
	Ontario	0.27	0.61	0.96
	Quebec	0.20	0.43	0.65
	Maritimes	0.02	0.017	0.05

Source: Table 6 is the source for the patent statistics, and the Canada Year Book the source for population figures.

CHART 4

TOTAL PATENTS GRANTED PER 10,000 OF POPULATION
BY REGION



declining to about one-half the 1926 level, the Prairies declining to just less than 30% of the 1926 level, Ontario to about 47% of the 1926 level, Quebec to approximately 53% of the 1926 level, and the Maritimes declining the farthest in percentage figures to about 8% of its 1926 figure. Thus, although the greatest absolute decline in the number of Independent patented inventions was in Ontario and the Prairies, 225.6 and 168 patented inventions respectively, the largest percentage decline was in the Maritimes and the Prairies, approximately 92% and 70% respectively.

For all regions, the Corporate class of patented inventions showed an increase from 1926 to 1969. Again, Ontario and Quebec rank first and second in terms of the absolute number of patented inventions, with B. C., the Prairies and the Maritimes following, in that order. Ontario and Quebec show the largest absolute increase in patented inventions from the Corporate sector, with 354.83 and 205. Combined, these two regions accounted for almost 85% of the Corporate class of patented inventions and just over 70% of those from the Independent class. In percentage figures, the increase in patented inventions of Corporate inventors was about 570% for B. C., approximately 590% for the Prairies, close to 460% for Ontario, nearly 475% for Quebec, and 350% for the Maritimes. Thus, the two regions with the

smallest absolute increase, the Prairies and the Maritimes, showed the largest and the smallest percentage increases.

The per capita figures are also quite informative. At the start of the century, British Columbia, Ontario and the Prairies were the most inventive regions. By 1951, Quebec had risen to the third position and by 1969, Ontario had replaced British Columbia as the most inventive region with Quebec the second most important region. These references to importance speak only of the quantity of patented inventions per capita and do not refer to the quality of the inventions coming from each region. Traditionally, Ontario, Quebec, and British Columbia, in that order, have been the most important sources of corporate inventions. With regard to independently derived inventions, British Columbia has always produced the most per capita, with Ontario second, except in 1951, where the Prairies placed second, and B. C. ranked third. All areas except the Maritimes have shown a trend toward producing more corporate inventions over time. Similarly, all areas had a declining trend in the number of independent inventions they produced. The most severe declines have occurred in British Columbia, Ontario and the Prairies. It has been this decline in the per capita output of independent inventions in B. C. and the Prairies, coupled with a stronger rise in the per capita output of corporate inventions in Ontario and Quebec,

which has dropped the former pair behind Ontario and Quebec in ranking as the most important sources of output of patented inventions per capita.

Another interesting fact is that the Prairies and the Maritimes, which fell into the bottom two positions in the rankings as sources of total patented inventions per capita, have not, as of 1969, produced more inventions in the corporate class than in the independent class. This, I believe, is a reflection of their industrial structures. Also, both of these areas have suffered a decline in the output of total patented inventions per capita through time, since 1926, and did not recover in 1969 as did the other three regions. Part of the decline in the Maritimes, and its generally low level of production of patented inventions, I believe, may be explainable. The explanation which I put forward is that many of the skilled and trained people of that region, who might otherwise have produced inventions there, have emigrated to other parts of Canada in search of better job opportunities. Along this same line of thought, it seems that the larger manufacturing bases of Ontario, Quebec and British Columbia have been contributing to the larger output of patented inventions in these regions.

This, then, concludes the chapter on the trends in, and the sources of, Canadian patented inventions in this century. In order to gain some insight into Canada's pro-

gress in producing patented inventions, it will be necessary to compare Canada's output with that of other countries. This is the purpose of the next chapter.

CHAPTER 4

CANADIAN OUTPUT OF PATENTED INVENTIONS COMPARED TO THAT OF OTHER COUNTRIES

The purpose of this chapter is to provide perspective for the Canadian statistics on the output of patented inventions which were presented in the preceding chapter. In an attempt to achieve this perspective, a comparison will be made between Canada's output of inventions and that of other countries who are leading producers of patented inventions. The analysis will be divided into two parts: the first part will contain a general comparison between Canada and a large group of selected countries; the second part will be a more detailed comparison between the Canadian output of patented inventions and that of the United States.

CANADA AND THE REST OF THE WORLD

The statistics that will be used in this section are not identical to those which have been gathered for Canada and presented in Chapter 3. The data employed in this section are concerned with world-wide filings of patent applications for 1968. Since this information is presented on the basis of the place of residence of the patent applicant, it is not directly comparable to the Canadian statistics in Chapter 3, which were gathered on the basis of the place of residence of the inventor.[1] In addition, the information presented in Table 8 does not allow for precise comparisons of the number of patent applications in each country, since the legislation covering the patenting of inventions differs with each country, although in many cases it is highly similar. A further weakness of this particular data is that an international corporation may apply for a patent in

all of the countries where it operates, and this would tend to exaggerate the total number of inventions without clarifying the country of origin of the invention. In spite of these difficulties, this data does allow for rough comparisons among the countries listed here, while recognizing the fragility of the conclusions arrived at by their use.

The purpose of this section is to gain an understanding of how Canada compares with the rest of the world in the production of inventions. Of the countries listed in Table 8, the first twenty-one in order of total patent applications account for approximately 90% of the total number of patent applications that were obtained in the world in 1968, and of these twenty-one countries, the first nine listed were responsible for approximately 70% of the total. Since applications may be made by both residents and non-residents of a country, and since this study is primarily concerned with the production of inventions by only the residents of a country, the figures in Table 8 have been worked to reflect this. The absolute figures are of little use for comparison, and so per capita figures are included in Column 3 of Table 8. As can be seen, the per capita rankings in some cases differ greatly from absolute rankings. For example, Canada, which ranked seventh in terms of the total number of patent applications from all sources, now is ranked twenty-second in terms of per capita patent applications by its residents. Canada's per capita ranking is somewhat surprising, in that it is so far down the list, grouped with countries such as Argentina and Mexico.

The fact that a country such as Canada has a great number of patent applications from foreign sources is not

TABLE 8

WORLDWIDE RANKING OF COUNTRIES
IN TERMS OF PATENT APPLICATIONS
1968

Countries Ranked by Total Applications by All Sources	Total Applications By Residents	Per Capita Applications By Residents (Per 10,000)	Per Capita Ranking
1. Japan	71,114	7.03	2
2. U.S.A.	67,180	3.34	12
3. West Germany	34,025	5.86	4
4. United Kingdom	26,711	4.83	5
5. France	17,561	3.52	8
6. Italy	7,604	1.44	16
7. Canada	1,591	.77	22
8. Switzerland	5,928	9.64	1
9. Netherlands	2,477	1.94	14
10. Sweden	4,692	5.93	3
11. Belgium	1,466	1.52	15
12. Australia	4,201	3.49	9
13. Mexico	2,983	.63	23
14. Spain	3,792	1.17	19
15. Austria	2,486	3.38	11
16. Czechoslavakia	5,879	4.09	6
17. South Africa	2,392	1.25	18
18. Brazil	2,763	.31	24
19. East Germany	5,441	3.40	10
20. Argentina	2,484	1.05	21
21. Poland	4,585	1.42	17
22. Denmark	527	1.08	20
23. India	1,217	.02	25
24. Norway	987	2.58	13
25. New Zealand	1,037	3.77	7

Source: B.I.R.P.I., Worldwide Patents - Filing For Protection, p.2-4.

unexpected. Canada is an important consumer of products produced with patented technology as well as a user of such technology. Moreover, the large number of foreign-owned and foreign-controlled firms in Canada whose parents are major contributors to patented technology ensures that the capacities of Canada as producer and consumer will not go unrecognized. Why a high level of consumption of products produced with technology creates an incentive to patent perhaps requires some explanation. Patents can be used to create a virtually impossible no-tariff trade barrier. Thus, a firm holding a patent in a particular country is able to treat it as a separate market, and to engage in international price discrimination, even in the absence of other barriers to trade such as tariffs or transportation costs. An additional reason accounting for the large number of patents granted to non-Canadian inventors is that, relative to a number of other highly industrialized countries, it is easier to obtain and cheaper to retain (i.e. absence of renewal fees) a patent in Canada.[3]

A more complicated question that arises from the ranking of per capita applications by residents is why one country outperforms any other. One hypothesis that may be presented is that it is the rate of growth of GNP rather than the level of growth that becomes important once the basic infrastructure has been established. The rationale for this argument is that the faster the rate of growth of GNP, the greater will be the demand for new technology, both to lower cost while increasing profits and to increase production possibilities in order to meet increasing demands. As well of course, there is a feedback from patented technology to economic growth. Therefore, the

hypothesis would be that there is a positive relationship between a high rate of patenting and a high rate of economic growth. Table 9 was compiled in order to follow up this hypothesis, although it is clearly not a test of the hypothesis. In Table 9, column one is a listing of countries ranked in order, from the highest to the lowest in terms of per capita patent applications by residents. The consumer Price index for each country is used as a rough deflator of GNP growth, allowing one to obtain an annual percentage increase in the growth of real GNP in column 5. The results of column 5 do not seem to support the hypothesis, since, for example, the percentage increase in the GNP of the twenty-third ranked country is higher than those of the countries ranked first and third. However, the ranking is a very arbitrary one, based on only one year, and the time period for GNP growth may not adequately represent the correct time period influence on inventive activity; that is, the actual lag may be greater than the one presented. Obviously, there are many factors which influence inventive activity, factors which cannot be easily isolated. I feel also that it is important to note that inventive activity and patenting activity are not necessarily affected by the same stimuli; for example, weak patenting laws may lead to keeping inventions secret where the invention can be easily copied and where there is a good deal of competition between firms who could benefit from the invention. On the other hand, this same situation could cause the original inventor to apply for a large number of secondary inventions which would protect the value of the original invention. Nevertheless, the rate of growth of GNP as an influence on inventive and patenting activity seems

TABLE 9

GROWTH OF GNP DEFLATED BY THE
CONSUMER PRICE INDEX
1965 - 1968

(In U.S. Dollars)

COUNTRY	% GROWTH OF GNP 1965 - 1968	CONSUMER PRICE GROWTH 1965-1968 1963 = 100%	REAL GROWTH IN GNP - 1965 - 1968	ANNUAL GROWTH IN REAL GNP
1) Switzerland	23.43	12	11.43	2.9
2) Japan	60.69	18	42.69	10.7
3) Sweden	25.35	12	13.35	3.3
4) West Germany	17.25	5	12.25	3.1
5) United Kingdom*	9.82	7	2.82	.9
6) Czechoslavakia	- -	- -	- -	- -
7) New Zealand**	5.37	11	- 5.63	- 1.9
8) France	27.62	12	15.63	3.9
9) Australia	30.03	10	20.03	5.0
10) East Germany	- -	- -	- -	- -
11) Austria	22.33	10	12.33	3.1
12) U.S.A.	26.50	12	14.50	3.6
13) Norway	28.34	14	14.34	3.6

TABLE 9
(Continued)

COUNTRY	% GROWTH OF GNP 1965 - 1968	CONSUMER PRICE GROWTH 1965-1968 1963 = 100%	REAL GROWTH IN GNP - 1965 - 1968	ANNUAL GROWTH IN REAL GNP
14) Netherlands	31.66	14	17.66	4.4
15) Belgium	22.02	10	12.02	3.0
16) Italy	26.95	7	19.95	4.9
17) Poland	- -	- -	- -	- -
18) South Africa	29.05	9	20.05	5.0
19) Spain	17.47	20	-- 3.53	- .9
20) Denmark	22.01	24	-- 1.99	- .5
21) Argentina	- 8.29	133	÷141.29	-35.7
22) Canada	29.05	12	17.05	4.3
23) Mexico	37.74	14	23.74	5.9
24) Brazil***	47.79	341	-293.21	-97.7
25) India	-18.03	27	- 45.03	-12.2

SOURCE:

United Nations, Yearbook of National Account Statistics 1969, Vol. I.

* Statistics for the U.K. and New Zealand are only presented for three years because of the effects of devaluation.

Statistics were not available for Brazil in 1968.

worthy of further analysis. However, Canada appears to lag behind most other developed countries in the production of patentable inventions.

COMPARISON WITH THE UNITED STATES

The lack of patent statistics for most countries prevents me from continuing this world-wide comparison of inventiveness, although such comparisons would obviously be useful. Therefore, what I propose to do is to focus attention for the remainder of the chapter on a comparison between Canada and the United States of America. The United States has been chosen for several reasons, the most important of which is the availability of a great fund of historical statistics. In addition, patenting, inventing and inventive activity have been studied in more depth in the United States than in any other country. Also, because of the physical proximity of the two countries, and because of political, commercial and sociological influences that the United States has on Canada, the United States seems a logical choice for such a comparison.

While comparisons in terms of patented inventions per capita are a more fruitful source of information, movements in the aggregate number of patented inventions are also useful for broad comparisons. As can be seen from Chart 5 and Table 10, the U.S. is and has been producing a larger number of patented inventions than has Canada, as one would have expected. Differences in the size of the populations and in the laws governing the patenting of inventions, as well as the standards used by patent office examinations, are several of the explanatory variables that first come to mind. There are also possible differences in the lags between the production of an invention and the granting of a

CHART 5

TOTAL INVENTIONS PATENTED IN CANADA
AND THE UNITED STATES SINCE 1921

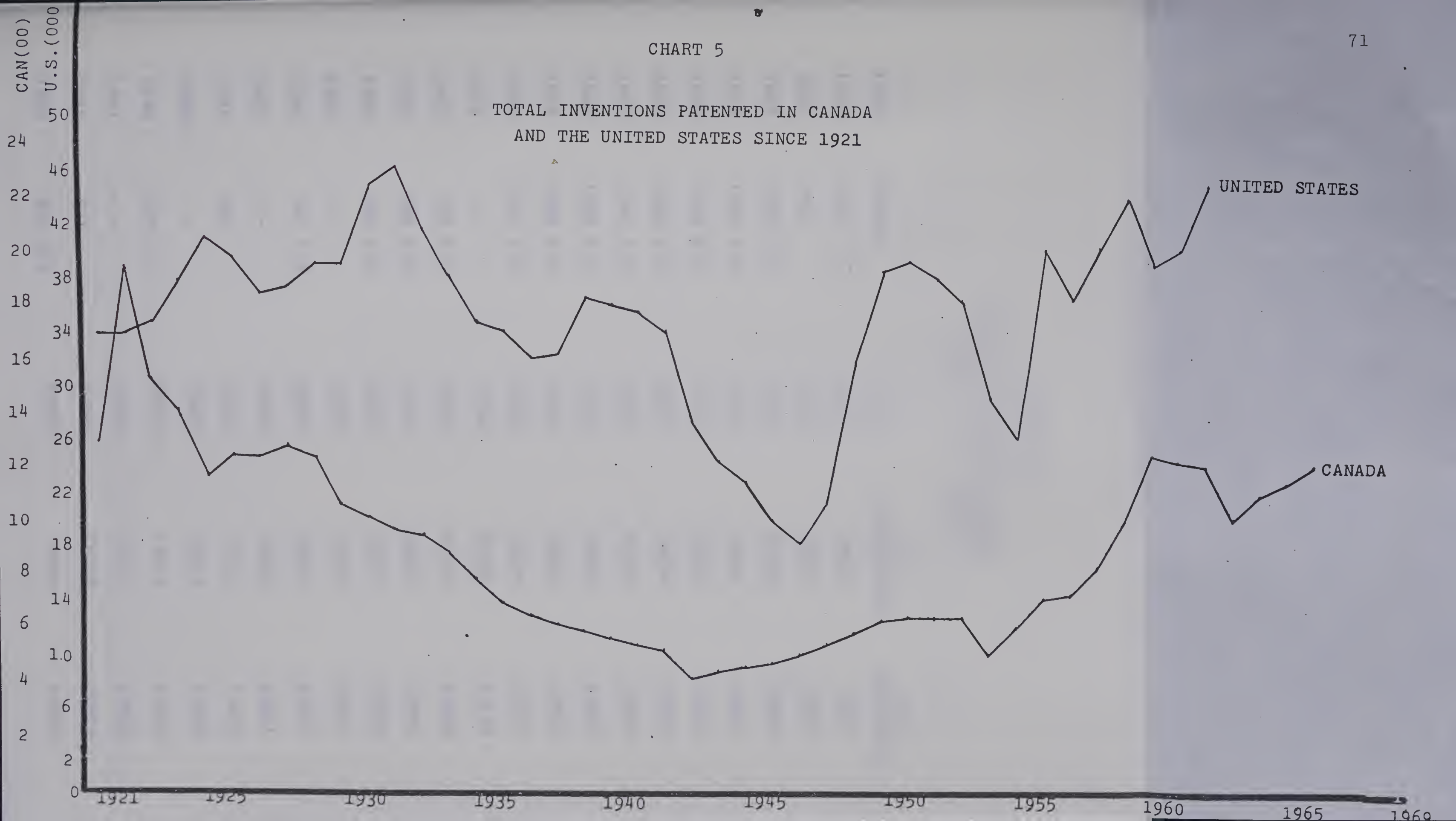


TABLE 10

PATENTS ISSUED IN CANADA
AND THE UNITED STATES
1921 - 1962

YEAR	CANADA	U.S.A.	U.S. INDEPENDENT	U.S. CORPORATE
1921	1285 1/2	33908	24048	9860
1922	1948	33996	23696	10300
1923	1501 1/3	34559	23759	10800
1924	1408 1/6	37938	25538	12400
1925	1176 2/3	41184	26384	14800
1926	1245 1/10	39630	24430	15200
1927	1245 1/6	36890	21790	15100
1928	1286 1/3	37236	19436	17800
1929	1233 1/3	39456	20956	18500
1930	1071 1/4	39254	19554	19700
1931	- -	45002	21825	23149
1932	975 2/3	46235	21376	24822
1933	956 1/2	41753	18035	23667
1934	894 5/6	38066	15507	22529
1935	- -	34762	13919	20821
1936	705 1/2	34167	12927	21207
1937	- -	32162	12298	19831
1938	634	32405	12711	19635
1939	- -	36867	15017	21800
1940	578 1/3	36218	14013	22165
1941	- -	35908	13233	22632
1942	531	34040	11959	22019
1943	435 5/6	27678	9608	18022

TABLE 10
(Continued)

YEAR	CANADA	U.S.A.	U.S. INDEPENDENT	U.S. CORPORATE
1944	475 1/3	24645	7770	16769
1945	- -	23245	7493	15665
1946	486	20040	6407	13486
1947	- -	18473	6870	11448
1948	559	21973	8498	13124
1949	- -	32065	13044	18536
1950	643 3/4	38708	16304	21782
1951	665	39533	16569	22305
1952	- -	38087	15052	22340
1953	658	36225	14337	21230
1954	514 1/3	29468	10491	18319
1955	- -	26451	9678	16084
1956	726 1/6	40309	13825	25502
1957	736 1/4	36593	12375	23255
1958	846 11/12	41089	12695	27116
1959	- -	44241	12931	29888
1960	1254 1/3	39483	10052	28187
1961	- -	40158	10334	28351
1962	1220 1/2	45649	11808	32560

SOURCES:

1) Canadian figures from TABLE 1

2) U.S. Figures from Statistical History of the United States, p.7 and p.16A.

patent in both countries, as well as a difference in the lags between the corporate and independent sectors. This fact would prevent exact year to year comparisons.

Of course, the aggregate statistics are not as illuminating as the per capita statistics. The latter figures for Canada and the U.S. are presented in Table 11, with the corporate and independent per capita statistics being transferred to Graph 6. These per capita statistics provide several interesting facts. A first observation concerns the growth in importance of the corporate sector relative to the independent sector as the prime source of patented inventions. During the 1921-1962 period shown in Graph 6, the corporate sector has surpassed the independent sector as the prime source of patented invention in both Canada and the United States. On the one hand, this is a natural outcome of the realization by the corporate sector of the importance of Research and Development both as a competitive weapon and as a marketing tool. This realization was followed by increasingly larger expenditures in Research and Development both for the actual work and for the physical plant. Allied with this was the growth of the skilled manpower involved in Research and Development activity.

A second observation that follows the first concerns itself with the decline in the independent sector as a source of patented inventions. This phenonemon occurs in both Canada and the U.S., but unlike the corporate source, it follows the same time pattern, from a high point in the early to mid-1920's to a low point in the early to mid-1940's. One likely source of this decline would seem to have been a trade-off in inventors between

TABLE 11

PATENTS ISSUED PER CAPITA BY SOURCE
FOR CANADA AND THE UNITED STATES
1921 - 1962

	CANADA		UNITED STATES	
YEAR	INDEPENDENT	CORPORATE	INDEPENDENT	CORPORATE
	(PER TEN THOUSAND)			
1921	1.37	0.09	2.22	0.91
1922	1.96	0.22	2.15	0.94
1923	1.49	0.18	2.12	0.96
1924	1.37	0.17	2.24	1.09
1925	1.09	0.17	2.28	1.28
1926	1.13	0.18	2.08	1.29
1927	1.10	0.19	1.83	1.27
1928	1.14	0.17	1.61	1.48
1929	1.01	0.22	1.72	1.52
1930	0.88	0.16	1.59	1.60
1931	- -	- -	1.76	1.86
1932	0.70	0.23	1.71	1.99
1933	0.68	0.21	1.43	1.88
1934	0.63	0.19	1.23	1.78
1935	- -	- -	1.09	1.63
1936	0.49	0.14	1.01	1.65
1937	- -	- -	0.95	1.54
1938	0.43	0.13	0.98	1.51
1939	- -	- -	1.15	1.66
1940	0.38	0.12	1.06	1.68
1941	- -	- -	0.99	1.70
1942	0.33	0.13	0.89	1.63

TABLE 11
(Continued)

	CANADA		UNITED STATES	
YEAR	INDEPENDENT	CORPORATE	INDEPENDENT	CORPORATE
1943	.28	.09	.70	1.32
1944	.28	0.11	0.56	1.21
1945	- -	- -	0.54	1.12
1946	0,30	0.09	0.45	0.95
1947	- -	- -	0.48	0.79
1948	0.33	0.10	0.58	0.90
1949	- -	- -	0.87	1.24
1950	0.34	0.12	1.07	1.44
1951	0.36	0.12	1.07	1.44
1952	- -	- -	0.96	1.42
1953	0.27	0.16	0.90	1.33
1954	0.21	0.12	0.65	1.13
1955	- -	- -	0.59	0.97
1956	0.25	0.18	0.82	1.52
1957	0.24	0.18	0.72	1.36
1958	0.25	0.21	0.73	1.56
1959	- -	- -	0.73	1.68
1960	0.31	0.35	0.56	1.56
1961	- -	- -	0.56	1.54
1962	0.31	0.32	0.63	1.74

SOURCE:

TABLE 11 and the Statistical History of the United States.

sectors, as potential independent inventors have channelled their energies into inventions that are appearing as corporately patented inventions. Such a trade-off appears more obvious in the U.S., although it cannot be regarded as not having occurred in Canada. Rather, it merely points out that such a trade-off is not the only explanation for the decline of the independent inventor as a source of patented inventions. There are a host of reasons, many of them given in the previous chapter, for this occurrence. Among the reasons hypothesized was that there was a psychological change in the attitude toward invention, such that the potential inventor felt that he needed to be a more highly-trained and better-financed individual. Hypothesized also was that a longer gestation period for inventions mixed with a faster pace of population growth caused the lengthening in the average time period necessary to produce and patent inventions. This then appeared as a decline in patented inventions produced per capita by independent inventors, and this decline rather than the strength of the increase in corporate inventions seems to account for the switch to the latter as the greatest source of patented inventions. Graph 6 points this out for Canada quite dramatically.

Another interesting question concerns the difference in timing in the growth in importance of the corporate sector between the two countries. Corporate inventions do not surpass independent inventions until some thirty years after the same phenomenon occurs in the United States. This would seem to be caused by two factors. The first of these is what Rostow would call the attainment of a future economy; that is, when a society has effectively applied the range of then modern technology to the bulk of its resources.[4]

Rostow estimated that this stage of development was achieved in the U.S. in 1900 and in Canada in 1950. This leads me to form a hypothesis about the impetus for the increase in corporate inventions, and that is that once existing technology has been applied in an economy, there is a drive to produce improved technology within industries, both to lower costs and improve profits and to gain an edge over competitors. In Graph 6 and Table 12, the increased production of patented inventions per capita by the corporate sector is quite evident in the U.S. after 1900 and in Canada after 1950. This upward drive in the U.S. was dampened by depression and war, but it is again approaching the levels reached in the early 1930's.

Following this line of thought, why then is the fifty year difference in attainment of a mature economy sliced to a thirty year differential in the time period during which the U.S. corporate sector surpasses the independent sector as the most important source of patented invention and the occurrence of the same phenomenon in Canada. There would appear to be several possible explanations for the change in the time lag. One explanation could be that the Canadian independent inventor as a source of patented invention per capita declined more emphatically as a source of inventions and did not rebound as much as in the United States. The data, however, is too inadequate to properly test this hypothesis. What seems to be a more likely explanation is that because of the incidence of American ownership of Canadian industry, the drive to innovate and invent, as well as the techniques used in R. and D., originated with the American parent firm and were passed on to the Canadian subsidiary, rather than

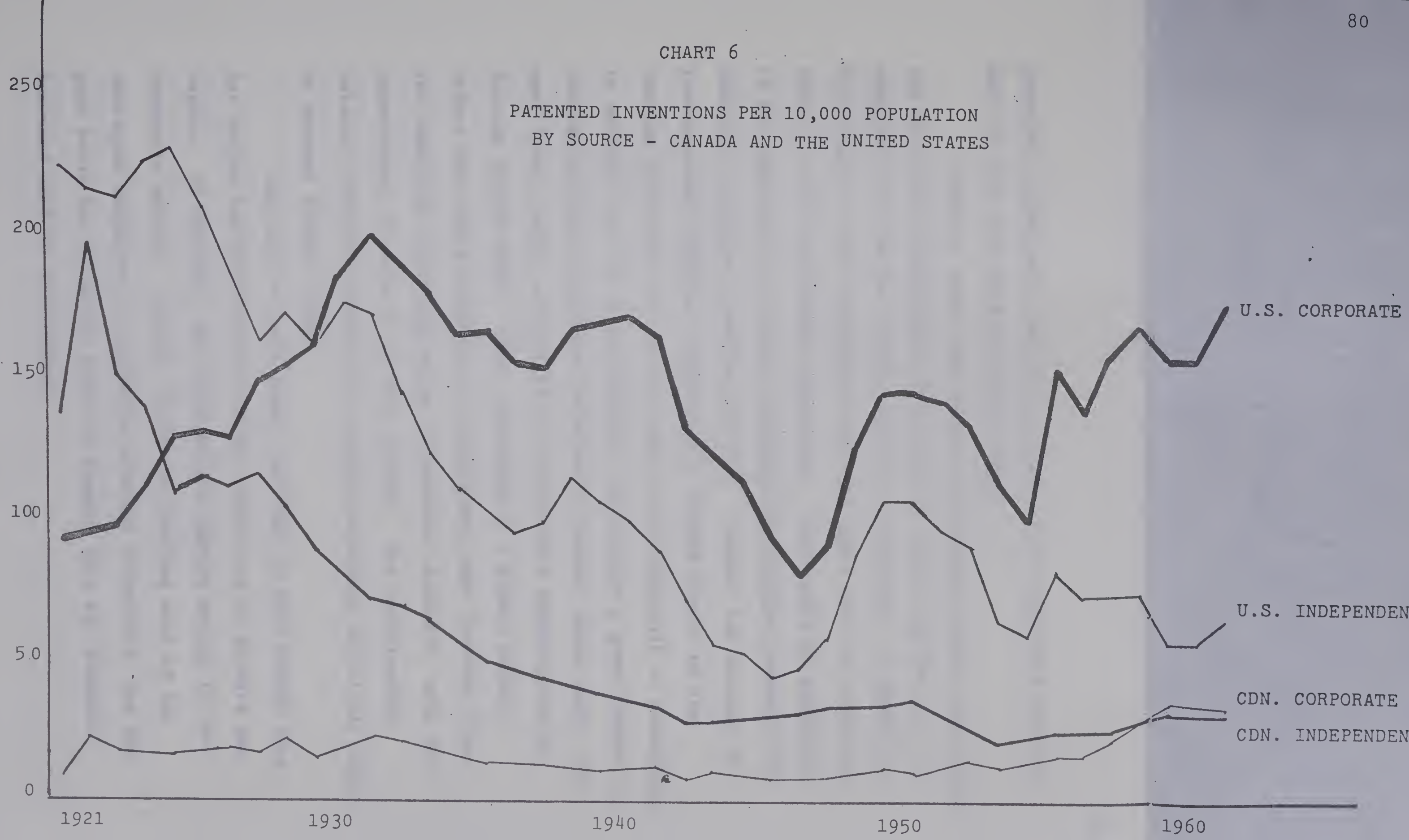
being evolved in Canada. In addition, these factors may also have caused the auxiliary effect of forcing Canadian-owned firms to compete along the same lines as the foreign-owned firms. All of these factors taken together would account for the accelerating of the process of inventing by Canadian firms.

Nevertheless, the Canadian corporate sector is far behind the U.S. corporate sector in the production of patented inventions. In 1962, the number of U.S. corporate patents per capita was 5.4 times greater than Canadian corporate patents per capita. Graph 6 quite effectively shows the differential between the two countries.

The independent sectors in the two countries are much more closely aligned. For example, in 1962, U.S. independent patents per capita were only 2.86 times greater than those in Canada, or approximately 53% of the difference in the corporate sector. Part of the differential in the independent sector is not unexpected. The United States holds a slight lead over Canada in educational attainment rates, and since the process of invention seems to have a positive relationship with the level of education, this would give the average American a slight advantage over the average Canadian. In addition, there would seem to be an income effect on the process of inventing, that is that inventing involves material costs. Therefore, the higher the level of income per capita, the more funds there are available to devote to inventing. Since the Canadian level of income per capita is only about two-thirds that of the United States, other things being equal, one would expect Canadian output of patented inventions from independent inventors to be about two-thirds that of American output. The difference, therefore, between the output of American and

CHART 6

PATENTED INVENTIONS PER 10,000 POPULATION
BY SOURCE - CANADA AND THE UNITED STATES



Canadian independent inventors is more easily explained and much more in line with what one might expect.

However, given the closer relationship between the figures for per capita independent inventions in Canada and the U.S. as compared with the per capita corporate inventions, (a spread of 2.86 times for the independents and 5.4 times for the corporate), there is need for further explanation. What could be suggested is the importance of foreign ownership of Canadian industry for Canadian corporate inventive activity. Indeed, the analogy of foreign-owned Canadian industry as a "branch plant" of the foreign parent may not in this case be too difficult to comprehend. In working with the Patent Gazette, one notices a great number of foreign-produced inventions patented in Canada, which could, and most likely would, be applied in the Canadian subsidiaries of foreign parent firms. Thus, according to a preset policy, rather than being producers of inventions, many Canadian firms are importing technology which is produced elsewhere, with the expectation of using it in this country. The relationship between inventive activity and foreign ownership definitely seems to warrant further study.

One fact is quite clear; and that is that Canada lags far behind the United States in the production of patents per capita. In addition, the differential appears mainly in the corporate sector. As well, Canada is trailing most of the developed countries in producing patented inventions, and the post World War II period does not suggest that any dramatic increase will be forthcoming.

CHAPTER 5

SUMMARY AND CONCLUSIONS

This study has been an attempt to understand the output and sources of invention in Canada. It is based on the tenet that patents may be used to measure the output of inventions within a country. While granting that patents are not the best possible measure, they are in fact the only source available for historical examination of inventions and inventive activity.

Throughout this work, a conscious effort has been made to point out those areas which seem to demand further analysis; two, however, seem to stand out. The first area of concern is that throughout this century there has been a gradual but constant shift from the independent inventor to the corporate inventor as the prime source of potential inventions in Canada. Moreover, since the early 1920's there has been a virtually continual decline in the number of patented inventions per capita produced in Canada. Although several possible explanations have been given for this phenomenon, further research seems necessary. Such additional research is necessary since the data that has been gathered does not indicate any reversal of the downward trend, especially in the Independent sector. Surely, any country with a technically oriented production system has need of ever improving and developing technology.

A second major area for further study concerns Canada's ranking as a producer of patented inventions. As was stated in Chapter 4, Canada ranked well down the list of developed countries as a producer of patented inventions, and there is no information

which would seem to indicate that there will be any significant change. The reasons for this country's ranking seem to demand further investigation, especially in light of Canada's need for advancing technology. More specifically, the problem of foreign ownership of Canadian industry seems to be most pertinent to this problem.

Inventions are being produced more frequently by Canada's corporations. As a result, the production of inventions is being concentrated in those regions of this country which have the most secondary industry, notably in Ontario, Quebec and British Columbia. Such a trend seems likely to continue.

The study of inventions covers a very large area. Although the importance of this subject is appreciated by most scholars, little has been done to explore it, especially as it pertains to Canada. While I have tried to point out several problems which I believe need further attention, the scope that is available for study is immense.

APPENDIX I

APPENDIX I

METHOD USED IN GATHERING CANADIAN PATENT STATISTICS

In collecting the data on Canadian patent statistics, I attempted to include only those inventions that were Canadian in origin. To do this, every entry in the Patent Gazette, which served as the source of the raw data, was examined for the years included in the study to determine which of all the patents issued were the work of Canadian inventors. Those patents which were Canadian were classified into three categories: independent, corporate and government, the specific category for a patent being decided according to the most likely inspiration for the invention.

The formula used in deciding whether an invention was Canadian and what was the source of the invention is the following:

1. If the patent is in the name of a Canadian resident who is listed as the inventor, then this patent is recorded as an Independent invention. Example: Patent No. 264,067

2. If the patent is in the name of more than

one Canadian resident, all of whom are listed as co-inventors, then this patent is recorded as an Independent invention. Example: Patent No. 130,471

3. If the patent is in the name of more than one individual and all are listed as co-inventors, and if one of these is a Canadian resident, then the invention is classified as an Independent invention. It is listed as a ratio of Canadians to all co-inventors. Thus, if there were two co-inventors, one being a Canadian resident and one not, it would be recorded as a ½ Independent invention. Example: Patent No. 140,369

4. If the patent is in the name of an individual or group of individuals, and has been assigned by a Canadian inventor, then the patent is listed as an Independent invention, regardless of the residence of the assignees. Example: Patent No. 264,857

5. If a Canadian is an assignee of a foreign inventor, then the patent is considered a foreign invention and is not included in the listings.

6. If a corporation, regardless of its country of residence, is the assignee of a Canadian resident, then the patent is categorized as a Corporate invention. Example: Patent No. 130,457
This is done under the assumption that the inventor is an employee of the corporation. There is, however, a possibility for conflict here as an independent in-

ventor may assign his invention to a corporation in which case there is a downward bias in the number of Independent inventions and an upward bias in the number of Corporate sponsored inventions.

7. If a corporation is the assignee of more than one individual, and at least one of these individuals is Canadian, then the patent is listed as a Corporate invention, and will appear as a ratio, the size of the ratio being determined as in (3) above. Example: Patent No. 130,460

8. If a Canadian corporation is the assignee of a non-Canadian inventor, then the patent is not included in the statistics. Example: Patent No. 137,003
The rationale for this is that the invention is not Canadian made, and has most likely been produced for a parent firm in another country.

9. If a government corporation, for example - Polymer Ltd., is the assignee of a Canadian inventor, then the patent is classified as a Corporate invention.
Example: Patent No. 563,889
This classification is used because the method of inventing would be very much the same as if the inventing were being done by a firm in the private sector.

10. If a government or one of its departments is the assignee of a Canadian inventor, then the patent is classified as a Government invention. The ratio rule, as

described in (3) also applies.

Example: Patent No. 657,599

11. If a charitable or non-profit institution is the assignee of a Canadian inventor, then the patent is categorized as an Independent invention. Example: Patent No. 277,187

While, supposedly, some of these patents could have been classified as Corporate and Government inventions, it seemed that these inventions were produced in a manner similar to that of an independent inventor. However, the number of these inventions is so small and spread through time that even if they should have been classified in another way, their impact on the statistics is quite small.

12. Patents that have been re-issued have not been included, for to do so would result in double counting. Example: Patent No. 173,723

13. In those cases where no place of residence has been given for the inventor, the patent has been assumed to be Canadian. The number of such cases has been very small and such an assumption will have little influence.

These criteria have been applied throughout the gathering of the Canadian patent statistics to ensure consistency and to ensure that the statistics represent Canadian output of inventions.

APPENDIX II

TABLE A

GROSS NATIONAL PRODUCT
AT MARKET PRICES
1935 - 1962

Year	G.N.P.	Year	G.N.P.
	millions of dollars		
1935	4,301	1949	16,300
1936	4,634	1950	17,955
1937	5,241	1951	21,060
1938	5,272	1952	24,042
1939	5,621	1953	25,327
1940	6,713	1954	25,233
1941	8,282	1955	27,895
1942	10,265	1956	31,374
1943	11,053	1957	32,907
1944	11,848	1958	34,094
1945	11,863	1959	36,266
1946	11,885	1960	37,775
1947	13,169	1961	39,080
1948	15,127	1962	42,353

Source: Dominion Bureau of Statistics, National Income and Expenditure Accounts, 1926-1968, 24-27.

TABLE B

INDUSTRIAL PRODUCTION,
VOLUME INDEX
(1949 = 100)
1935 - 1962

Year	Index	Year	Index
1935	41.4	1949	100.0
1936	45.7	1950	106.9
1937	52.3	1951	116.6
1938	49.6	1952	120.9
1939	53.3	1953	129.1
1940	63.9	1954	128.5
1941	80.1	1955	142.3
1942	94.7	1956	154.9
1943	100.5	1957	155.4
1944	101.3	1958	154.4
1945	90.1	1959	166.1
1946	83.8	1960	167.4
1947	91.5	1961	179.9
1948	96.4	1962	186.0

Source: Dominion Bureau of Statistics, Canadian Statistical Review; Historical Summary, 1963, 16.

TABLE C

PATENTED INVENTIONS PER 10,000 MEMBERS
OF THE LABOUR FORCE
1921 - 1969[a]

Year	Per Member	Year	Per Member
1921	3.88	1939	--
1922	5.76	1940	1.26
1923	4.37	1941	--
1924	4.02	1942	1.16
1925	3.29	1943	0.95
1926	3.40	1944	1.05
1927	3.31	1945	--
1928	3.33	1946	1.00
1929	3.11	1947	--
1930	2.64	1948	1.13
1931	--	1949	--
1932	2.32	1950	1.25
1933	2.24	1951	1.28
1934	2.06	1952	--
1935	--	1953	1.23
1936	1.58	1954	0.93
1937	--	1955	--
1938	1.38	1956	1.25

TABLE C
(Continued)

Year	Per Member	Year	Per Member
1957	1.27	1964	1.59
1958	1.34	1965	--
1959	--	1966	1.65
1960	1.96	1967	--
1961	--	1968	--
1962	1.85	1969	1.70
1963	1.51		

SOURCE:
Invention Statistics have been taken from TABLE 1, and labour force (civilian) figures from the Canada Year Book.

[a] Does not include labour force statistics from Newfoundland.

FOOTNOTES

Chapter 1

[1]Economic Council of Canada, Fifth Annual Review, 39.

[2]Jacob Schmookler, Invention and Economic Growth, 7.

[3]Jacob Schmookler, "Technological Change and Economic Growth," American Economic Review: Papers and Proceedings (1965), 335.

Chapter 2

[1]Government of Canada, Patent Act, 1935, 1.

[2]Jacob Schmookler, Invention and Economic Growth, 6.

[3]Simon Kuznets, "Inventive Activity: Problems of Definition and Measurement," The Rate and Direction of Inventive Activity, 20.

[4]Jacob Schmookler, 8-9.

[5]Barkev Sanders, "Speedy Entry of Patented Inventions into Commercial Use," Patent Trademark and Copyright Journal of Research and Education, (Spring, 1962).

[6]J. J. Brown, Ideas in Exile, 342.

[7]Ibid., 245.

[8]Jacob Schmookler, "The Interpretation of Patent Statistics," Journal of the Patent Office Society (February, 1950), 124.

[9]Barkev Sanders, 91.

[10]Jacob Schmookler, "The Interpretation of Patent Statistics", 126-128.

[11]J. J. Brown, The Inventors, 7.

[12]Frederic M. Scherer, et al., Patents and the Corporation, 48.

[13]Ibid., 153.

[14]Robert K. Merton, "Fluctuations in the Rate of Industrial Invention," Quarterly Journal of Economics (1935), 455-456.

[15]Fritz Machlup, "An Economic Review of the Patent System," Study No. 15 of the Subcommittee on Patents, Trademarks and Copyrights (1958), 11.

[16]Jacob Schmookler, "Patent Application Statistics as an Index of Inventive Activity," Journal of the Patent Office Society (August, 1953), 540-541.

Chapter 3

[1]Jacob Schmookler, Invention and Economic Growth, 22.

[2]Alfred B. Stafford, "Is the Rate of Invention Declining?", The American Journal of Sociology (May, 1952), 541.

[3]Richard E. Caves and Richard H. Holton, The Canadian Economy, 71.

[4]Alfred B. Stafford, 543-44.

[5]Barkev Sanders, "The Upgrading of Patented Inventions", Patent, Trademark, Copyright Journal of Research and Education (1963), 186.

[6]S. C. Gilfillan, The Sociology of Invention, 111-112.

[7]Ibid., 112.

[8]John Jewkes, David Sawers and Richard Stillerman, The Sources of Invention, 91.

[9]Ibid., 90.

[10]J. J. Brown, Ideas in Exile, 219.

[11]Dominion Bureau of Statistics, National Income and Expenditure Accounts 1926-1928, 25-27.

[12]Canada, Department of Trade and Commerce, Public and Private Investment in Canada, 36-37.

[13]Frederic M. Scherer et al., Patents and the Corporation, 47-49.

[14]Andrew H. Wilson, Science, Technology and Innovation, Special Study No. 8 prepared for the Economic Council of Canada, 129.

[15]Report to the Economic Council of Canada by the Advisory Committee on Industrial Research and Technology, A General Incentive Programme to Encourage Research and Development in Canadian Industry (1965), 9.

Chapter 4

1 B.I.R.P.I., Worldwide Patents - Filing for Protection, p. 2-4

2 Ibid.

3 The Economic Council of Canada, Report on Intellectual & Industrial Property, 1971, Chpt. 4.

4 W. W. Rostow, The Stage of Economic Growth, 59.

5 Ibid.

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